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The Need of Stream Gaugings.

It is a little discouraging to have annually to raise one's voice in defense of the valuable hydrographic work carried on by the United States Geological Survey. It goes without saying that exact knowledge of the flow conditions in the streams of our country is of vast importance to their proper development. And the material interests involved are of a magnitude that, when realized, commands instant attention. For example, the unutilized hydraulic horse-power in the Southern Appalachian region is known to be in the neighborhood of 2,000,000. Appraising this at, say $5 per horse-power-year, the annual value rises to $10,000,000 and a fair capitalization at 4 per cent. amounts to $250,000,000 which is not a small sum, even in these days of large finance. The practical value of these hydraulic resources depends, aside from the raw value, on the knowledge of the conditions of economical utilization. It is certainly a proper function of the government to examine national resources of such importance, and the Geological Survey is, from the nature of its general work, the proper department to charge with the task. The fine Geological Survey maps furnish the best, and in many cases the only, available information on the subject of streams having power possibilities and in the surveys leading to these maps it is a very simple matter to lay the foundations for an investigation of the hydraulic conditions found on the various streams.

Gauging stations are indispensable to the proper knowledge of flow, which determines in turn the problem of economical utilization, and a proper knowledge of flow involves the extent and character of drainage area and the possibilities of storage, both of which are directly in the present province of the Geological Survey. The last time the subject came up in Congress, some purely controversial objections were raised against the continuance by the Geological Survey of the gauging it had been conducting for a dozen years. It is difficult to see why a work which has already the sanction of long usage should have been objected to then, but in order to remove any such protests a special bill has now been introduced to set at rest any legal doubts as to the matter. This emphatically ought to pass, so as to leave the way absolutely clear for the annual appropriation of $200,000 which Congress for several years made for this work. It is an amount none too large, but if expended wisely, is still able to accomplish work of great value. The continuity of work is very important, since the data already gathered cover time enough to make the observations of the next few years of especial value. Occasional or discontinuous gaugings are unsatisfactory, since the power available on a stream without considerable storage requires for its determination a knowledge of the flow in one of those exceptionally dry periods which come at rather long intervals. The lowest flow in a given decade is generally larger than that determined by the records of a quarter century and hence the value of gaugings increases rapidly with the extent of time they cover.

Incidentally this hydrographic work gives valuable information on the effects of the deforestation which is rapidly going on, and knowledge of this sort is a necessary preliminary to the application of an intelligent remedy. The evil results of deforestation do not appear suddenly, but are cumulative in their nature. In a large way they are painfully evident in the conditions found in some parts of the West, but information regarding the progress of the action is rather meagre. It can probably be most quickly obtained by observation of some relatively small streams for which the recent history of the watershed can be readily ascertained. At the present rate of depletion of the coal supply, which has now reached in this country the tremendous total of about 400,000,000 tons annually as against less than 300,000,000 tons only five years ago, the preservation of water powers will soon become of the utmost importance. And if present estimates are not badly at fault the timber resources of the country will be actually exhausted during the lifetime of the present generation, perhaps in as short a time as twenty years. It is therefore of immediate importance to look well to the water powers—not something that can very comfortably be put off indefinitely. The Geological Survey has shown already that it can do the work and do it well. The task is directly in line with other valuable work of the Survey and can be carried on more economically in connection therewith than independently or under the auspices of any other department. It ought to be given ample resources for carrying out the hydrographic work continuously and thoroughly. It therefore behooves all those who are interested in the hydraulic resources of the country to busy themselves in the furtherance of this investigation and to use what influence they can command to push through the necessary appropriations.

Volume and Efficiency in Industrial Production.

The relation between volume and efficiency of production is one of the most important matters to be considered in the study of modern industrial conditions and methods. The cost of handling a fixed traffic, of supplying a constant demand upon output, and of producing routine repeat orders need be determined but once so long as the unit cost of labor and materials remains fixed. In actual commercial production these costs change from time to time; the fact is recognized by all sound executive policies, and variations from the average cost are not likely to swing far up or down the scale before the discovery is made that the old conditions no longer obtain. Few manufacturers of machinery can safely assume that the labor percentage in figuring shop cost will remain unaltered from year to year, even in producing the same line of equipment. Aside from these periodic changes in the factors which make up productive cost, there are the more sudden flunctuations in unit expense, and perhaps in quality of output as well, which are due mainly to great variations in the volume produced, whether that be expressed in ton-miles handled, in kilowatt-hours generated or in pieces of apparatus shipped to the purchaser.

In the stress of handling excessive volumes of business, minor economics tend to disappear, and hence bids made to meet rush order requirements must be higher than would be the case if more accurate data existed on the cost and quality of rush jobs. The purchaser may be willing to pay the extra cost—he must be, in fact, to secure the promise of earlier delivery—but the fact remains that excesses in estimates due to imperfect knowledge are actually economic lost motion. Undue profits due to excessive estimates on any single order tie up just so much capital that otherwise might be available for expansion or improvement on the purchaser's side, and they tend toward possible loss of the future business to the producer through his inability to figure closer than his competitors. It is clearly desirable that the cost of unit production and the influence of large output upon quality should be very carefully analyzed, not only to enable close figures to be made in future work, but also to assure the management of each overloaded company that a reasonable profit is made upon each unit sold.

It is manifestly difficult in many lines of production to turn out an excessively large volume of business at as high efficiency as is possible, and often realized, at normal rates of output. Taking the cases of the railroad, the central station and the factory as typical, it is apparent that while all three of these industrial machines differ radically in conditions of operation, the efficiency with which they work tends to fall as the volume of the output exceeds certain critical points above normal. Up to a certain point, which few operating railway men have definitely determined for specific conditions, each increase in traffic can be hauled at less expense per ton-mile. When this point is passed, the cost of handling each unit rises. Additional motive power becomes necessary out of proportion to the train load; minor accidents to draft gear stall the equipment on the road, or the speed of train movement, including classification in yards and terminals, becomes so slow that the blocking of the lines delays traffic generally.

In the case of the central station excessive overloads do not mean a lower quality of product except in the incidental phase of reduced voltage at the consumers' premises, but the actual cost of production rises at too fast a rate. Excessive depreciation, overheating of equipment, higher steam, gas or fuel consumption per kilowatt-hour, premature breakdown and partial paralysis of service caused by forcing the plant far beyond its guaranteed safe overload capacity, are the evils of too large output, to say nothing of the strain upon the operating force at such times. In the factory, forced output tends to lower the quality of the product unless inspection is increased to a large degree, and beyond a certain point aisles and bays become choked with stock and partly completed equipment. An influx of large numbers of new employees to meet rush conditions opens the way toward a larger percentage of spoiled work and a lower production rate per hand. In all three of these industries the point where congestion begins is the place where additional traffic or output can be handled only at a less efficient rate.

To recognize the approach of the congestion point and to ward it off as much as possible is the problem of the highly developed industrial organization. Net earnings are the index of efficiency, taken in connection with unit volumes and with allowances for expenditures leading toward permanent betterment. It is no doubt beyond the control of the most astute manager to forestall extraordinary demands upon his plant or system at certain times by being prepared to handle the business at nearly the same efficiency as is obtained in the normal course of production. But so far as this can be done the returns will be commensurate with the importance of the problem. In railroad service the extending use of electric motive power in regions where the traffic is very dense, and particularly the adoption of the multiple unit principles of train control, will help greatly in producing transportation at the minimum total cost per unit handled. We are only beginning to write the equations connecting the flexibility of electric motive power in handling varying volumes of traffic with its annual cash value on given systems, but it is already clear that entirely new results and new points of view attend the financial as well as the physical aspects of steam railroad electrification.

In all industries where the hand of the engineer is constantly felt in the administration of the plant, provision for expansion of equipment and property is bound to receive more and more attention as time passes, in its relation to the economical handling of large volumes of business. There is no denying that the securing of efficiency under overload conditions is a hard nut to crack, and in the long run it must be obtained by the extension of the unit of organization and equipment, that unit being highly developed by experience and labor-saving methods. Much depends upon the suddenness of the extraordinary demand upon the system. It is the old question of individual overload capacity contrasted with a larger initial installation of spare facilities. Cumbersome methods, preventable wastes, internal friction, and inability to gauge the future all stand in the way of efficient production in large volumes of output. The development of understudies in all important departments cannot be overlooked without danger that when the rush days and hours come, the right men to direct and stimulate economical forced production will be wanting. The limitations of each plant and system are worth finding out, and there is no more interesting task than to endeavor to increase capacity without increasing the cost of production per unit of output or injuring the quality of the product. Such problems demand the keenest analytical skill on the part of the engineer, and they constitute a useful example of a field which those with the peculiar qualifications needed will find fertile for many years to come.

Garbage and Refuse Disposal.

Some decidedly interesting indications of the present indeterminate nature of the available information regarding the disposal of garbage and refuse were apparent last month in proceedings at Milwaukee and Columbus. The former city, as those familiar with garbage disposal matters are aware, has had a long and uniformly unsuccessful experience in trying to dispose of its wastes of this nature. Before making another attempt to solve this problem, some of the city officials decided to take the advice of a specialist, and Dr. Rudolph Hering, of New York was retained to investigate the matter. The unsatisfactory conditions in Milwaukee were, he reported, chiefly a lack of sufficient capacity in the existing plant and a very large expense for running it. In making an examination of these conditions, Dr. Hering studied not only the incineration of garbage, but also the disposal of other refuse and the collection of all these wastes. The consideration of collection involves certainty concerning the location of the disposal works. On account of the invariable offensive character of reduction works he was acquainted with, he decided that they should be located at Mequon, 13 miles from the city, where such a plant had previously been operated. A crematory, however, need cause no offense, and the proper site for such furnaces was fixed in the city on water-front property owned by the municipality. This location is also practically the best place for delivering the collected garbage and refuse. In the case of disposal by reduction, the additional cartage and railway charges are estimated at 70 cents a ton for the garbage. An incinerator must be built to burn the paper, wood and other refuse which cannot be sent to the reduction works, and this should preferably be located at the site suggested for the crematory.

In estimating the comparative cost of disposal by the two methods, Dr. Hering assumed 150 tons of garbage daily as the quantity to be handled. With a reduction plant for the garbage he has also estimated that an incinerator of 100 tons capacity must be provided. The reduction plant was estimated at $225,000, and the net cost of transporting garbage to it and operating it at $55 a day. The incinerator was figured at $89,000 and its daily operating charges at $37.73. The net cost of reducing the garbage and burning the refuse was estimated at 37 cents per ton of all materials, after allowing for the sale of the products of the plants. A crematory large enough to burn 450 tons was estimated at $307,000, and the cost of running it at 10 cents per ton, if it is operated at its full capacity. A 300-ton crematory was estimated to cost $200,000, and its running expenses at about 26 cents a ton. In the case of both crematories some return was estimated from the operation of the plants, but just what this profitable feature of incineration was is not stated in the abstract of Dr. Hering's report made public at Milwaukee. On the basis of these figures, Dr. Hering recommended the construction of a 300-ton crematory, with provisions for its extension as needed.

This report is particularly interesting because of the fact that the city of Columbus, after practically adopting in 1906 the same method of disposal by incineration recommended for Milwaukee, has begun advertising within a month for a reduction plant. The report by Mr. John H. Gregory, endorsed by Dr. Hering, which recommended cremation of the Columbus refuse was reviewed at length in this journal on March 24, 1906, and was one of the most complete studies of the subject yet made for an American city, being excelled in this respect only by the investigation conducted by Mr. J. T. Fetherston for the Borough of Richmond, New York City, and reviewed in this journal last week. At the time Messrs. Hering and Gregory made their investigation the garbage of the city was treated in reduction works by a private company at a loss. The ashes and refuse were collected separately from the garbage, and the local conditions are such that a continuation of this practice was considered imperative. Consequently the garbage to be disposed of contains an exceptionally large amount of organic matter and water, and its incineration is peculiarly difficult. Nevertheless incineration was considered the best method of disposal in 1906, mainly on account of the lack of definite information regarding the details of operation of reduction plants and the practicability of controlling them in such a way as to make them satisfactory as a measure of municipal sanitation.

The change in Columbus from this opinion to that favorable to reduction has been mainly due, it is understood, to the excellent results with that system in Cleveland, which have furnished details of operating methods and expenses hitherto unavailable to the engineer. The success at Cleveland has led the Department of Public Service of Columbus, on the advice of Mr. Gregory, to determine to build a reduction plant near the sewage disposal works about four miles from the city. The specifications call for a plant capable of treating 100 tons of garbage and dead animals in 24 hours, with provisions for adding equipment for treating 50 tons more without interfering with the operation of the original installation. No consideration will be given to proposals based on methods that have not passed the experimental stage successfully, nor to apparatus of unknown or untried types. The bidder is required to guarantee the amount of labor and fuel required to run the plant. The process must be so conducted that after the digesters are charged no products will be exposed to the air until rendered non-putrescible and containing less than 10 per cent. of moisture. All gases emitted from the apparatus and all air passing over heated materials must be passed through furnaces, and all waste water, which is likely to be very offensive, must be evaporated. The oil and grease must be produced in a merchantable condition, and the tankage must not carry over 3 per cent. of moisture and 1 per cent. of grease and oil. One-tenth of the contract price is to be withheld for a year from the completion of satisfactory trials lasting sixty days, to pay for repairs due to defects in designs, materials or workmanship. If the number of man-hours of labor or pounds of coal per ton of garbage reduced exceed the guarantees, the contract provides for deductions from the contract price, while the impracticability of operating the plant in a sanitary manner without causing a nuisance will result in the rejection of the works.

If the city of Milwaukee constructs a crematory under the advice of Dr. Hering, this plant and that of the Borough of Richmond, now under construction, ought to yield results of the highest value regarding the incineration of mixed refuse in a scientifically correct manner. At the present time we are without such information from American sources, and until we have it the discussion of crematory methods and improvements depends to an undesirable extent on judgment alone. There is even less information to be had regarding the reduction process, and for this reason the results at Cleveland and Columbus will prove of particular importance. Until it is definitely known what the garbage reduction process will do when operated as a sanitary measure and not as a source of profit primarily, there is a great probability that its availability will be underestimated, at least that is the recent lesson of the plant at Cleveland. There is no reason for expecting that either method of disposal will prove preferable for all cities, but it is certain that at the present time the line between their appropriate fields is not located.

Notes and Comments.

EXCAVATION on the Northern Pacific R. R. during the month of October on all classes of work, including double-tracking, grade reduction, and new spurs is reported to have totaled 3,432,928 cu. yd., which is roughly about 1½ million yards more than was moved on the Panama Canal during the same period. The work is scattered through all the states from Wisconsin to the Pacific Ocean through which the Northen Pacific runs.

MATHEMATICAL INSTRUCTION for engineering students was pretty thoroughly discussed this week at the convention of the American Association for the Advancement of Science. Two joint meetings of Section A, Mathematics and Astronomy, of Section D, Mechanical Science and Engineering, and of the Chicago Section of the American Mathematical Society were held, and eminent engineers and professors took part in the discussions or submitted communications. It cannot be said that any new light was thrown on the subject. Some of the mathematicians present seemed to fear that any attempt to make mathematics interesting to the average engineering student would destroy part of the value of the subject as a source of mental training, being seemingly of the opinion that the more disagreeable and apparently useless a study was, the higher its position in learned circles. These people appeared afraid to say much on the floor during the meetings, but they were in evidence, nevertheless, and fully upheld the traditions of the class of which a shining light was the late Professor Sylvester, who once rejoiced publicly that his mathematical researches had no useful application. The value of mathematics as one of the resources of the engineer was thoroughly well stated by many of those present, and the sentiment was strongly toward making the instruction in it as interesting as possible by using problems based on engineering work. This is already done in most good technical colleges. There was also some approval expressed for carrying forward more than a single branch of mathematics at a time, rather than completing one before taking up another. This is the next step in rational mathematical instruction for engineers, but its day is not yet here, to judge from the talk of those at the convention. There was unanimity on one point, however, and that was the poor quality of preparation in mathematics of those who enter technical colleges. Some of the professors at the meetings were frank in saying privately that there was little hope for real strides in mathematical work in engineering classes until those in them are better trained in preparatory schools. This is particularly the case in State colleges, which are practically unable to enforce strict entrance requirements.

THE FAMOUS MORTON STREET TUNNEL under the North River between Hoboken and New York was crossed on Dec. 28 by an electric car, the first to run through it, and regular service will be begun in a few weeks. In some respects this is the most famous tunnel in the country. Work on it began in 1874 and was continued intermittently until 1882, when operations were stopped. A serious accident occurred during these early days, which unquestionably did much to retard the development of subaqueous tunneling in this country for a number of years. Later, after the shield method of tunneling had been developed in England, a company was formed there to complete the North River tunnel. The contract was taken by the same company that is now constructing the East River tunnel of the Pennsylvania R. R., but the work was soon abandoned on account of lack of funds. Finally the New York & New Jersey Railroad Co. was organized to undertake the work and Mr. Charles M. Jacobs was retained as chief engineer. The construction has been carried along since then with marked success, and both tubes of the tunnel have been completed for some time. Work on the approaches has been pushed forward vigorously and it is now expected that by October cars will be running from Hoboken to Herald Square in New York, while the Manhattan approach as far north as Fourteenth St. will be opened to the public in a month.

PATENTED PAVEMENTS have been excluded from use in New York City by a charter clause reading as follows: "Except for repairs no patented pavement shall be laid, and no patented articles shall be advertised for, contracted for, or purchased, except under such circumstances that there can be a fair and reasonable opportunity for competition, the conditions to secure which shall be prescribed by the Board of Estimate and Apportionment." In 1903 a contract was awarded by the city to Warren Brothers Co. for bitulithic pavement, but shortly afterward the Appellate Division rendered a decision in another case involving the same principle which held that such a contract was illegal under the clause quoted. It should be stated that in the case under consideration, bids for sheet asphalt, block asphalt and bitulithic had been called for, in order to secure competition. The Warrens at once brought suit against the city for $5,000, their estimated profits on the contract, and after protracted litigation the Court of Appeals decided a few days ago that the contract was valid and the city must pay the sum mentioned. The court rules that there was competition in the sense intended by the charter provision quoted, and contains this summary of the principle involved: "It may well be in this age of invention and progress that the wit of man may devise, if it has not already, a smooth and noiseless pavement that is cheaper and more enduring than any now in use. If this proves to be the fact, there is no reason why the inventor and the city should not profit by this situation." While there are some States in which a contrary decision has been reached, there can be no question that engineers engaged in municipal affairs believe that the public is best served by giving them discretion regarding the use of patented materials and methods. An enormous amount of patented or copyrighted material is bought annually by every important city for one purpose or another without arousing comment, but when some patented product is offered in connection with engineering work a protest is pretty certain to arise. It is right and proper to prevent any injudicious favoritism toward proprietary products, but there are other ways of preventing this than the wholesale prohibition of the use of all patented materials.

THE PANAMA CANAL CHANGES authorized a few days ago by President Roosevelt, on the recommendation of Lieut.-Col. Goethals, are very important. They include the abandonment of Lake Soza and the construction instead of a dam and locks at Miraflores, about four miles further inland, which will be reached from the Bay of Panama by a dredged channel 500 ft. wide. The old plan called for two dams, respectively one and one and a quarter miles long, a spillway from Lake Soza to the Bay, and the relocation of the Panama R. R. A feature of it that has been severely criticized was the practicability of destroying the canal's usefulness by a naval attack, since the dams and locks could be easily injured sufficiently to close the canal by a bombardment from the sea. The location of the dam and locks at Miraflores follows the French project, and is not only advisable for military reasons, but reduces the length of the water-retaining embankments to about half a mile. Test pits sunk at the site indicate that satisfactory foundations can be reached without difficulty. The construction of the four-mile channel by dredging is expected to be relatively inexpensive work, and the channel will be large enough to permit vessels to move up to the locks from the Bay at about full speed. The Commission has a fleet of dredges at Panama and some of them can be put at work on the channel now, if necessary, so that there is no question regarding the practicability of completing it before the Gatun dam is finished. It should be added that the War Department never formally adopted the location of locks at La Boca, and hence there has been no change in its plans, but the alteration consists of a modification of the plans recommended by the minority of the Board of Advisory Engineers. As there was no necessity of deciding the matter until a thorough study of the problem had been made, the determination of the plan for the Pacific end of the canal was wisely deferred until everything had been investigated which had any influence. The Gatun dam is now recognized to be the controlling feature of the undertaking, as was predicted long ago in these columns, and the Culebra cut has lost all its features of doubt and trouble. It is understood that no uncertainty is felt concerning the Gatun dam work outside of its unusual character, which makes it difficult to estimate just how long it will take to put the enormous masses of material into their final place.

ENGINEERING FEATURES OF THE SOUTHWEST SMELTING AND REFINING WORKS, JARILLA JUNCTION, N. MEX.

The new copper smelting works of the Southwest Smelting & Refining Co., at Jarilla Junction, N. M., are built according to the most modern practice that has been evolved in the operation of such works. Although these new works are of moderate size, they are as entirely complete as larger plants built for the same service, and embody numerous special features of design and construction peculiar to an installation of this kind, or required by the local conditions. The works were erected to reduce copper ores from mines about three miles distant, the ore being delivered in bottom-dump standard-gauge cars over a railroad connection to the mines.

The general arrangement of the buildings of the works is shown in an accompanying illustration. The ore is delivered to storage bins along a track on a trestle at one side of the works. From these bins it is transported, as required, to a 50x80-ft., two-story building containing one blast furnace and providing space for a second one. A large brick dust flue, 200 ft. long, extends from this building to a 9-ft., self-supporting steel stack, 125 ft. high. Power for operating the works is supplied from equipment in a 70x76-ft. brick power house adjacent to the furnace building. In the rear of this power house is a 20x48-ft. brick building containing a machine shop, carpenter shop and blacksmith shop, each completely supplied with the equipment necessary for making practically all the repairs required about the works, as the latter are in an extremely isolated region. A sampling plant is installed in a small building at one end of the ore bins, and a storage house is the only remaining building. A gravity water-supply system, involving the construction of two storage reservoirs and 25 miles of pipe line, was also built in connection with the works.

The track trestle at the ore bins has a total length of 740 ft., the first 320 ft. being on a 5 per cent. grade, and the remainder on a 0.3 per cent. ascent, with a height of 21 ft. above the ground at the high end. This trestle is of ordinary timber construction, built according to general practice. A track scales is placed in the switch leading up to the approach to the trestle. The ore bins along the side of the trestle are 300 ft. in length, 14 ft. wide, and have a capacity for storing 1,200 tons of ore. At the end of the ore bins is a coke storage bin. The ore and coke are drawn from gates in the sides of the bins into two-wheel steel carts in which they are transported by hand to the furnace building. These buggies are weighed, en route to the furnace, on scales placed in the runway from the bins.

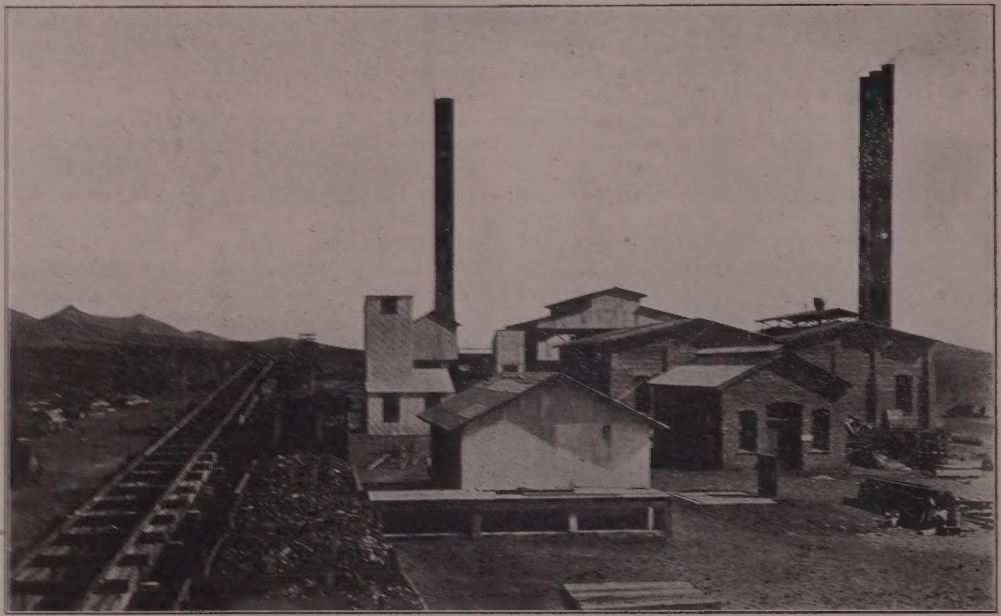
Blast Furnace Building and Furnace.—The two-story furnace building has a structural steel frame, with the columns of this frame on concrete footings. The first story of the building is entirely open of the sides and ends, as the blast furnaces are drawn practically at the ground level, and the climate is such that the temperature is rarely low. The second story is 12 ft. 2 in. in height and is sided with galvanized corrugated sheet-iron; the roof of the building is of the same material. The sheet iron is placed over a layer of sheet asbestos, supported by wire netting, for protection against the fumes emitted by the furnaces. The roof is carried by light steel trusses on the steel frame, thus avoiding any columns on the second floor. A monitor, with open sides, surmounts the center line of the roof, and a space, 4½ ft. wide, is left open in the sides and ends of the second story for ventilation.

The first story of the building is divided into two bays, by a row of columns on the transverse center line. The blast furnace which has been installed has its center line coincident with the center line of one of these bays, and the other furnace, when it is built, is arranged to occupy a similar position in the second bay. A blast furnace of the general type used in modern smelter works has been built. This furnace is somewhat similar in construction and operation to the furnaces employed in reducing iron ore, but differs from them materially in several essential features. The furnace is rectangular in cross-section, the sides and ends of the lower portion consisting of steel water-jackets, and the upper part of brick masonry, with a fire-brick lining. Ore and coke are raised to the level of the second floor of the building in the buggies by a pair of motor-driven balanced platform hoists in a tower at one side of the building. They are charged from the buggies into any one of three doors in the side of the furnace, the second floor of the building being built of reinforced concrete to take the load and wear incident to this work.

An air blast is supplied to the furnace through tuyere connections at the bottom, and is operated at a pressure considerably below the pressures commonly employed in iron-ore blast furnaces, since the heat required to reduce the copper ore is much less than that necessary to reduce the iron ores. This blast is also furnished by volumetric rotary blowers instead of the positive blowers generally used in iron-ore blast furnaces, so the pressure is regulated by the nature of the charge in the furnace. The result is that the top of the charge in the copper matte smelting furnace is comparatively cool, no flame appearing at the charging doors. Since the top of the furnace is also closed and a connection to the dust flue is made in the side just below the closed top, the amount of heat and fumes reaching the charging-room floor is small.

The molten ore is continuously drawn from the bottom of the furnace, at either end, into a circular tank, lined with fire brick, which is termed the fore hearth. The slag, being lighter than the molten matte, or copper concentrate, rises to the surface and is drawn off into small dump or slag cars through an opening in the side of the fore hearth. The matte is drawn into similar cars through an opening lower down in the fore hearth and is shipped to a converting plant.

The furnace that has been installed in these works has a total height of 32 ft. 10 in. from the floor of the first story of the building to the top of the brick masonry. The water-jacket portion is 14.5 ft. high, the bottom of the furnace proper being 4 ft. above the floor. This portion is built with its sides slightly battered to form a hopper, the ends being vertical. This hopper is 3.5 x 14 ft. in cross section at the bottom and 4 ft. 10 in. by 14 ft. at the top. The vertical component of the weight of water-jacket portion of the furnace and of the load in the latter are carried by a separate flat-bottom seal to the hopper. This seal is built of 2-in. cast-iron segments and is lined with fire brick. The horizontal component of the weight and load, due to the batter of the sides of the furnace, is transmitted to two pairs of 12-in. 31.5-lb. I-beams, carried by four steel columns which support the upper brick portion of the furnace. The portable bottom is carried by eight jack-screws, in two rows of four each, which are mounted on an eight-wheel steel-frame truck on a 4-ft. gauge track. This construction permits the bottom to be lowered and rolled out from beneath the furnace when repairs are required.

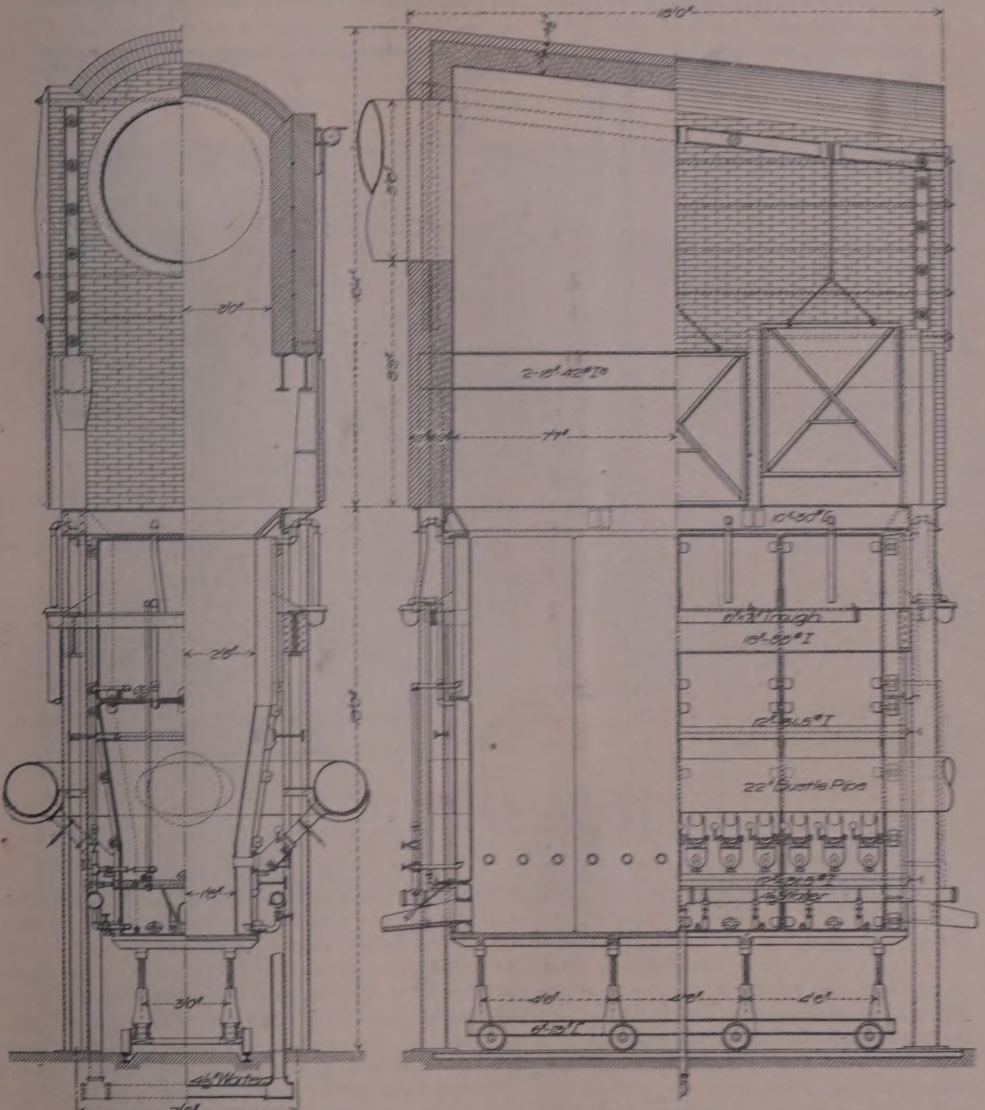


General View of the Smelting Works.

The water jackets for the sides of the furnace are made in single vertical sections, 3.5 ft. wide and 13.5 ft. long. The end jackets are made the full width of the furnace, but are each divided horizontally into two parts. This division permits the lower part, which is close to the tap hole where the wear is the greatest, to be removed and replaced without requiring the renewal of the whole end.

The jackets are made of steel plates and provide a water space, 6 in. wide, around the entire furnace. Water is admitted to each section of the jacket through two 1¼-in. holes in the outer side close to the bottom and is drawn off at the top, in order to insure circulation. The connections at the top are carried up in a bend above the top of the jackets, and then down to an open trough along the side of the furnace, the cooling water being run to waste. This arrangement with the raised bend in the draw-off connections avoids the collection of air and steam in the top of the jackets, although, normally, sufficient cooling water is supplied to prevent the generation of steam.

The construction of the jackets is such that an entirely smooth surface is presented on the inside of the furnace. The inner-face of the jackets is formed of ⅜-in. inner plates and the outer face of ⅝-in. plates. The ⅜-in. plate of the inner face of each jacket is continuous and is bent to form the ends of the jacket, its connection with the ⅜-in. rear-face plate being a flanged joint. The inner-face plate of each jacket is braced against the rear-face plate by a trussed brace, placed on the vertical center line of the jacket. This brace consists of four 1¾x1¾x5/16-in. angles placed together in pairs, and the pairs latticed together with ¼x1¼-in. lacing to form the truss brace. The latter is riveted to the rear-face plate, but simply bears against the inside of the front-face plate. As all rivets on the inside of the furnace are thus avoided by the flanged joints between the rear and front-face plates, and by the method of placing the braces in the jacket sections; the chief cause of leaks in the jackets is overcome and the tendency of the charge to collect on the sides of the furnace, or to arch is reduced.



Arrangement and Construction of Copper Matte Smelting Furnace

The air blast is supplied by the blowers in the power house through a 30-in. pipe extending overhead to the furnace building. A 30-in. connection to this main supply pipe is extended to the furnace that has been installed and a second connection of the same size could be provided for a future furnace. The 30-in. connection is separated at the furnace into two 22-in. branches, one of which extends along each side of the furnace, 5 ft. above the bottom of the latter. Each of these branches is connected at intervals of 14 in. with the tuyeres through which the blast is introduced to the furnace, 2.5 ft. above the bottom, the tuyere openings being 3½ in. in diameter. At each connection between the branch supply line and the tuyeres a flanged coupling is riveted to the supply line, and the connection between this flange and the tuyere casting is made by a piece of 5-in. well casing, with a gate valve in each of these connections to control the flow of air. Both ends of each connection are fitted into a gland packed with asbestos, in order to allow for changes in position due to variations in temperature. A 2-in. circular hole, closed with card-board, is placed in the bottom of each tuyere casting, so in case the furnace becomes choked and the slag enters the tuyere openings it will burn out the card-boards closing these 2-in. holes and be carried off, without filling the tuyeres.

The brick upper section of the furnace has a total height of 16 ft. 4 in. and has 18-in. walls, consisting of a two-course wall of ordinary brick masonry on the outside and a 9-in. lining of fire brick. The top of this upper section is a flat semi-circular arch, with a single course of ordinary brick on the outside and a 9-in. lining of fire brick. This brickwork is all carried, independently of the water-jacket portion of the furnace, by four built-up steel columns, one at each corner. Each of these columns consists of two 10-in., 15-lb. channels latticed together with ¼ by 1¼-in. lacing bars, except where connection plates are required. The two columns at each end are 7.5 ft. apart on centers and at the sides are 16 ft. 8 in. apart on centers. Each side wall of the brickwork is carried by two 15-in., 45-lb. I-beams between the columns, and each end wall is carried by two 10-in., 15-lb. channels, with a ¼-in. plate riveted on top. The columns have a total length of 22 ft. 4¾ in., but are braced together by a set of laterals 3.5 ft. below the line of the charging floor, and by the I-beams which transmit to them the horizontal thrust of the water-jacket portion of the furnace, so they are sufficiently rigid. The down-take connection leading from the top of the furnace to the dust flue is 5.5-ft. steel pipe at the furnace, where it is connected to a 6x6-in. angle set as a collar in the brickwork.

Dust Flue.—The 200-ft. dust flue is built of brick masonry on a concrete base. Above the invert its cross section is formed by an inverted catenary curve, with a span of 16 ft. at the bottom. This construction could be used because no live load will ever be brought on the structure. It required a minimum amount of material, as the 16-ft. span arch is built of two rings of brick laid in cement mortar. The invert of the flue is pitched sharply toward the center from both sides, the center being 4 ft. below the sides. A motor-driven horizontal flight-conveyor is placed on the center line of the invert and extends the full length of the dust flue. This conveyor is covered by a light hood of sheet steel, which does not extend down on the sides to the invert, so dust can reach it in the lower flight. The conveyor delivers at the inlet end of the dust flue to an inclined bucket elevator, which discharges at the top into an elevated storage bin. This arrangement is believed to be original in this plant, the usual method being to remove the accumulations in the dust flue by hand, such work being quite disagreeable and expensive.

Steel Stack.—The self-supporting steel stack at the end of the dust flue is on a concrete base, 20 x 20 ft. in plan at the top, 24 ft. high and 26 x 26 ft. in plan at the bottom, which rests on a good natural foundation. The stack is 15 ft. in diameter at the base, and is reduced slightly at each 5-ft. horizontal joint until the diameter is 9 ft. at 35 ft. above the base, the balance of the stack being of that size. The stack is anchored to the base by sixteen 2½-in. bolts, 26 ft. long, which are attached to brackets on the lowest section of the stack. It is built of boiler-plate steel, in 5-ft. vertical sections, each section consisting of three plates, with vertical butt joints. To a height of 40 ft. the horizontal joints between sections are double riveted, and above that they are all single riveted. Up to 45 ft. above the base, ⅜-in. plates and ¾-in. rivets were used; in the next 45 ft., 5/16-in. plates and ¾-in. rivets, and in the top 35 ft., ¼-in. plates and ⅝-in. rivets. All plates were lapped 3 in. in the single-riveted joints and the rivets were spaced 3 in. apart on centers; in the double-riveted joints the plates were lapped 5½ in., and the rivets spaced 2¾ in., with those in the two rows staggered. Although this construction may appear light, it is considered to be well within reasonable safety, the stack having, in fact, withstood several severe wind storms.

Power House.—The 70x76-ft. power house is a brick structure with a wooden roof, covered with prepared felt and carried by light steel trusses. The interior of the building is divided by a longitudinal brick wall into a 36x70-ft. boiler room and a 40x70-ft. engine room. The boiler room contains three single-drum 150-h.-p. Heine water-tube boilers, with space for a fourth boiler of the same capacity. The three boilers are in a continuous brick setting, each boiler being provided with a separate steel stack, 100 ft. high. Coal is delivered from a switch track along one side of the building and the boilers are fired by hand. The steam-consuming units in the engine-room are operated non-condensing, their exhausts being connected to a 12-in. main leading under the floor to a Wainwright feed-water heater in the boiler-room. A connection is also provided beyond the heater so the exhaust may pass direct to the atmosphere. Two Smith-Vaile center-packed 6x4x6-in. pumps deliver feed-water from the heater to the boilers.

Each boiler has a 5-in. connection to a 10-in. overhead steam main along the engine-room side. Each of these connections is fitted with a gate valve, and the header is also fitted with several gate valves, so it can be separated into different sections. Each of the steam-consuming units in the engine-room is connected to the 10-in. header.

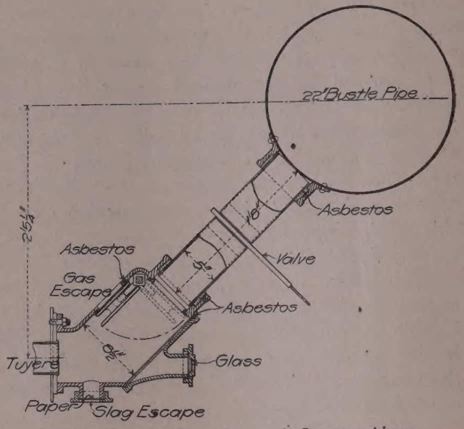
The engine-room contains two No. 8 Connersville rotary blowers, and two 60-kw., 220-volt, direct-current General Electric generators. The blowers are each direct connected to a 12x30-in. simple Filer & Stowell Corliss enbine. They supply the air blast used in operating the blast furnace, and are in duplicate, either one having sufficient capacity to operate both furnaces contemplated in the original design. The generators, also in duplicate, are each direct connected to a 12x13-in. high-speed Chuse engine. These generators supply power for various motors around the works and for lighting.

Gravity Water Supply System.—The gravity water-supply system built in connection with the smelter works is an example of the extensive construction commonly required in the semi-arid regions of the western part of the country to obtain a satisfactory supply of water for industrial and domestic purposes. In this particular locality the rainfall is light, the evaporation is high and streams are rare. Two possible ways of obtaining water existed, one by drilling or boring wells, and the other by bringing water about 45 miles from the Sacramento River by gravity. The results obtained previously by drilling wells in the region in which the works are located had been very discouraging, both as to quantity and quality. An analysis of the water from an adjacent well showed 3.18 lb. of incrusting solids per 1,000 gal. of water, and is a typical example of the character of the well water obtainable. Investigations of the amount of flow in the Sacramento River, and of the character of the water, showed both to be satisfactory. The quality of the well water, the uncertainty of obtaining a well, or wells, of sufficient flow and the consequent cost of pumping, made it imperative that wells be abandoned as a source of supply, and water brought from the river by ditch and pipe line, if the latter could be done at a reasonable cost.

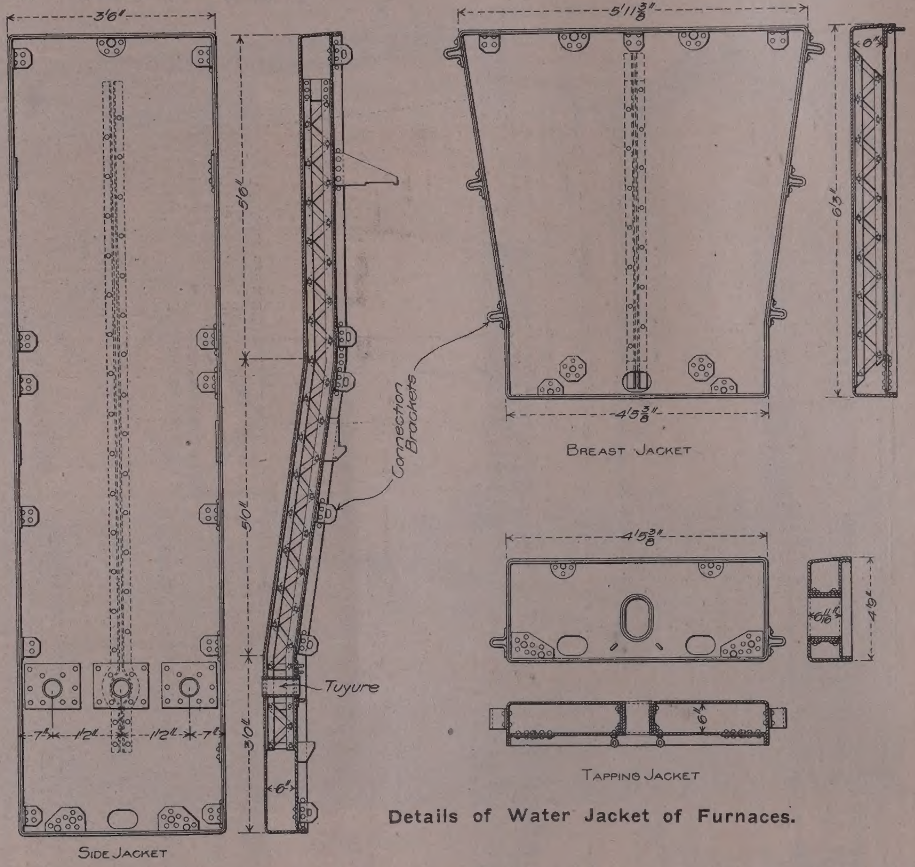
The Sacramento River has its source in numerous springs in the Sacramento Mountains, at an elevation of 7,300 to 8,600 ft. above sea level and some 55 miles from the smelter works. Some of these springs are intermittent, giving up no water during the dry season. No records of the flow of the river were available, but measurements made during a stage above normal showed a flow of 30,000,000 gal. in 24 hr. on one occasion, and at a second time, 60 days later, a flow of 40,000,000 gal. From a knowledge of the local conditions, it was considered conservative to conclude that the dry weather flow would be at least one-tenth of the maximum. These measurements were made about 15 miles from the permanent springs where a ranchman had built a diverting ditch over 20 years ago and appropriated 4,000,000 gal. of water from the stream. This ditch was 20 miles long, and extended generally in the direction of the smelter works, delivering the water to small storage reservoirs. The water that is not diverted into the ditch from the river flows on down stream and is lost in the sands of the desert some 7 or 8 miles below the head-works.

The ditch, water rights, right-of-way and improvements were purchased, except that the cattleman was to be furnished 50,000 gal. of water per 24 hr. The ditch was enlarged and arranged to deliver into a 10,000,000-gal. storage reservoir, 20 miles from the intake at the river, the fall in this distance being about 1,400 ft. From this storage reservoir a 25-mile pipe line was built to a 25,000,000-gal. storage reservoir adjacent to the smelter works. The water flows from this latter reservoir to the smelter and town, with an effective head of 175 ft.

It was estimated that the daily needs of the smelter and the town in connection with it would be 200,000 to 250,000 gal. a day, but to allow for additions to both, the decision was made to build a pipe line capable of carrying about 500,000 gal. in 24 hr. The difference in head between the two reservoirs is close to 1,500 ft., so the following equation was used to determine the flow in a 6-in. pipe: $(V^2 \div 2g) + 4f (lv^2 \div 2dg) = h$. In this, l represents the length = 132,000 ft.; d, the diameter of the pipe in feet = 0.5; f, the coefficient of friction = 0.007, and h, the static head = 1,500 ft. From these values it was determined that the 6-in. pipe could carry 470,000 gal. in 24 hr. The coefficient of friction is larger than usually employed for the lap-welded steel pipe used, but was chosen thus to insure the delivery of the requisite quantity of water. After the construction was started the conclusion was made to carry the water for some 2 miles from the upper storage reservoir in a ditch, thus reducing the head to 900 ft. When the pipe line was finished it delivered 385,000 gal. of water in 24 hr. under this 900-ft. head.



Details of Tuyere and Connections.



Details of Water Jacket of Furnaces.

The 6-in. lap-welded steel pipe of which the flow line is built is made for high-pressure service, and was tested to a pressure of 1,500 lb. per square inch. The shell of the pipe is 0.28 in. thick and weighs 18.76 lb. per foot; the total gross weight of all the pipe was about 1,300 tons. The pipe was made in random lengths, which were coated inside and out with asphalt. The connections between the lengths were made with patented recessed screw couplings. In order to facilitate repairs in case of a break a flanged coupling was substituted for the regulation screw couplings at every 1,000 ft. in the pipe. In an emergency 500 ft. would thus be the greatest distance from one of these special couplings at which the pipe could be disconnected readily.

The special flanged couplings were forged out of steel. The flange has an outside diameter of 12½ in. and is 1¼ in. thick. An 8-in. hub, 1 in. thick, placed on the pipe side of the flange has an ⅛-in. recess, 6⅝ in. in diameter, fitted around the pipe. Holes for twelve ¾-in. bolts were drilled in the flange, on a 10-in. circle. Sheet-lead gaskets, 3/16 in. thick, were placed between the flanges. The inner diameter of these gaskets was cut ¼ in. larger than the diameter of the pipe, so when the joint was bolted up tight the gasket would just about come to the inside of the pipe. These flanged joints have given satisfactory service under the existing high head on the pipe line.

The pipe was laid 24 in. under the surface and well covered. No expansion joints were provided, as difficulties due to expansion and contraction were considered to be avoided by the high velocity of the water in the pipe and by the 2-ft. covering. At one point where the line passes over a slight ridge between two canyons an automatic air relief valve was provided. The profile of the line is such that no other air valves were necessary. A blow-off valve was placed at the lowest point in the line, so the pipe can be drained from either end.

When the calculations were made for the pipe line, it was hoped that some water power might be developed. The amount of water available, however, made this impracticable, as to obtain about 135 electrical horse-power, 19 or 20 miles of 12-in. pipe would have been required, so the scheme was abandoned.

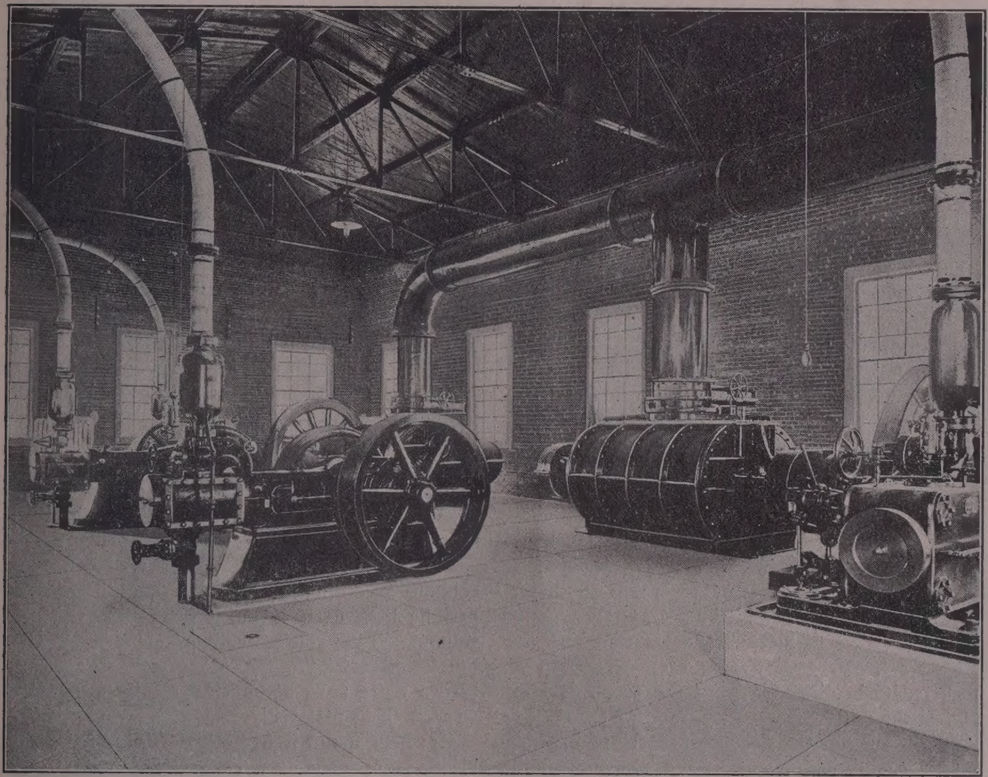
The 10,000,000-gal. reservoir site at the upper end of the pipe line was developed by constructing an earth dam containing about 15,000 cu. yd. of material. This dam is 625 ft. long and has a maximum height of 29 ft. It has a slope of 2 to 1 on the water side and 1 to 1 on the outside. The material in the dam is a black loamy clay, mixed with disintegrated rock and calechi. The latter is a leached limestone, impervious to water. The combination of the materials packs and holds water perfectly, thus forming an excellent dam.

The dam of the 25,000,000-gal. reservoir at the discharge end of the pipe line is also of earth, and contains about 50,000 cu. yd. of material. It has a maximum height of 40 ft. and is 750 ft. long and 12 ft. wide on top. The slope on the water side was made 3 to 1, and that on the outer side 1½ to 1. The materials in this dam are similar to those in the smaller dam, the soil being somewhat more sandy. The slope on the water side of the dam was faced with 1 ft. of calechi in order that an impervious lining might be secured.

After the dam sites had been staked out, all vegetation was removed and the top soil loosened to form a good joint with the materials of the embankments. The latter were built with drag scrapers. All of the materials were inspected, no clods of large size peing permitted, and the mixture of broken stone, gravel, sand, soil and calechi was well packed by the teams on the scrapers.

The cost of the completed water-supply system, including the construction of the two dams and the pipe line was close to $100,000. In considering this low cost it must be remembered that in the region where this work was done skilled labor is scarce, living expenses are high, freight on materials is considerable and conditions generally are of such a nature that construction costs are higher than in less isolated localities.

The plans for the smelting works and water supply system were prepared by Mr. Thomas L. Wilkinson, consulting engineer of Denver, Colo., and the construction work was carried on under his supervision.



Interior of Engine Room in Power Plant of Smelting Works.

Mill Construction to Prevent Fires.

According to Mr. Charles H. Fish, M. Am. Soc. C. E., the agent of the Cocheco Mfg. Co., of Dover, N. H., hardly a day passes without a list of cotton mill fires, more or less serious, and new causes for them, not before given, are constantly being suggested. This led him to prepare an important paper on the general questions of cotton mill fires, for the last meeting of the National Association of Cotton Manufacturers, from which paper the following notes have been taken.

It does not take a long apprenticeship or connection with the cotton manufacturing before one is introduced to the cotton mill fire, in some of its various forms. The general character of the work invites fires. There are more fires, large and small, in the cotton mills, than in any other business, aside perhaps from those where dangerous chemicals or explosives are employed in the processes. The causes are many. First, we have every opportunity for fire from friction. This friction may come from some of the numerous bearings on shafting or machinery, or from the rubbing of belts against woodwork, or maybe from the friction caused by foreign bodies passing into or through the machines with the stock. Then there is spontaneous combustion, always possible, in one form or another, although in the modern mills where cleanliness is maintained, the chance for spontaneous combustion is greatly diminished. Then there is the carelessness of employes, a factor of considerable importance.

With the conditions which invariably exist in cotton mills, although in some departments to more extent than in others, the fire must be under control immediately, or great damage may result. We are all familiar with the inflammable quality of cotton fibre, especially when in light or fluffy condition. We all know what a delight oil soaked floors and woodwork must be to the devouring elements. It is a well known fact that a fire in a bale of compressed cotton cannot be easily extinguished, largely from the fact that it is difficult to get water onto that part, or all parts, of the cotton which is on fire. As far as the water reaches, it does its work instantly and effectively, but no matter what force the stream of water may have, it cannot penetrate a compressed bale of cotton, nor can it penetrate to any distance a pile of loose or opened-up cotton as found in the opening rooms. Bales of cotton which have fire in them can be sunk under water for hours without extinguishing the fire, which breaks out again as soon as the cotton is opened to the air. The same characteristics, in a less degree, apply to oil-soaked beams and general woodwork, after they have once become thoroughly heated. If a fire once extinguished would stay extinguished, the difficulties of the situation would be largely removed.

For an illustration of a cotton mill fire, Mr. Fish described the destruction of the No. 1 mill of the Cocheco Mfg. Co., on Jan. 26, 1907. The main mill is 400 ft. long, 74 ft. wide, and five stories high. Running directly back from the centre of the main mill was an ell four stories high, 200 ft. long and 74 ft. wide. The mill had wooden posts throughout, of ample size, with the usual cast iron caps and pintles. Double floor-beams were used entirely, each made up of two beams, 7x16 in., bolted together but separated by blocks or washers about ¾ in. thick. This made a space in the center of every double beam, at least ¾ in. wide, and 16 in. deep or high, but owing to the shrinkage of the beams, these open spaces were often considerably more than ¾ in. wide.

The ell was divided from the main mill, on every floor, with a brick wall with fire doors, but this wall was cut through in several places by wide belt holes where the main belts from the engine passed through to the head line shafting in the main mill. There were four towers, two on the front and two on the back, each 25 ft. square, with wide stairways in three of them, and an elevator in the fourth. There was also a wide stairway at the end of the ell connecting with every floor, and a fire escape on the outside connecting from the roof to the ground. The sprinkler system covering the entire mill was divided into three sections, two of these sections, of equal size, covering the main mill, and the third taking the entire ell. Each section was independent of the other and was controlled by its own valve, these valves being located in the hallways on the first floor.

There were six standpipes, one in each of the four towers, one at the center of the mill, and one at the end of the ell, each with hose connections on every floor. The city water pressure, which was always on the mill, had a standard pressure of 110 lb. In the pump house at the rear of the mill was one Blake fire pump of 1,200 gal. capacity, supplementing the city pressure on the hydrants in the immediate vicinity. In addition to the nine mill hydrants, there were six city hydrants, which were in use throughout the fire. Connecting with the No. 1 mill system, there were two large rotary pumps driven with the water wheels in No. 2 and No. 3 mills, and a 1,000-gal. Worthington underwriters' fire pump at No. 10 mill, all of which did good work at the time of the fire, the No. 10 pump having a record of 58 hours' continuous service against 170 lb. water pressure, running at maximum speed for the entire time, with the exception of a few minutes when it was slowed down on account of the slacking up of the water supply. There was also, in addition, a 500-gal. underwriters' pump in continuous service from the plant of I. B. Williams & Sons, located nearby.

On the morning of Saturday, Jan. 26, a fire broke out in the center of the card room on the third floor. The weather conditions at the time were extreme, the thermometer outside ranging in the vicinity of 25° below zero, in fact at no time during the fire did the mercury get above the zero mark. This intense cold, coupled with the fact that double beams were used in the construction, is responsible for the extent of the damage.

On the morning in question the mill started at the usual hour, 6:10 o'clock, and shortly afterwards a sprinkler head on the fourth, or spinning room, floor went off for some cause unknown. Promptly in accordance with instructions the overseer of this department ordered the sprinkler valve controlling this section of sprinklers shut off, and the drip opened, in order to quickly drain the pipes, and then proceeded with all haste to take up the water which covered the floor, to prevent its running through onto the machinery below. While the men were engaged in this work, they suddenly detected smoke coming up through one of the large main belt boxes. This belt passed through the card room below, but was boxed up to a height of only 6 ft. from the floor. Looking down through the belt box, fire was seen running over the tops of the cans of drawing.

Here is a strange coincidence, that a fire should start in one department, within not over three to five minutes after the water was shut off from the sprinklers for a minor repair in another department, but this is the fact. The real cause of the fire will never be known, although several theories, more or less plausible, have been advanced. From the testimony of some of the witnesses, the fire seemed to start from one of the main belt boxes. The location of the sprinkler head which went off in the spinning room was such that this main belt may have become wet, causing it to slide or slip sideways on the pulley, until it touched the woodwork of the belt box, starting fire from the friction.

The overseer and the employees in the card room, innocent of the fact that the water was shut off the sprinklers, did the best they could with fire buckets, and a line of hose from the standpipe, wondering all the time why the sprinkler heads did not operate, but they were quickly driven back by the rush of flame and smoke. In the meantime, the overseer in the spinning room above, after discovering that there was a fire below, rushed down to the main valve and it was opened as promptly as possible. There was some delay here, however, owing to the crowding of the operatives through the hallways, they having already received warning and were hurrying out. The spread of the fire was so rapid through the card room that many of the sprinklers in this room were melted off, making so many openings that when the water was turned on, the pressure in the mains was greatly reduced, interfering with the efficiency of the sprinklers. Within five to seven minutes of the starting of the fire, the pressure in the mains showed on the gauge less than 60 lb. In the meantime, the fire was forcing its way through the rest of the card room, opening all the sprinkler heads in the other section, and quickly finding its way into the ell, through the belt openings, it passed down the belt boxes to the main engine room below, melting off sprinkler heads everywhere with impunity, until finally, in order to make the hose streams available, the sprinkler system had to be abandoned, all valves being closed tight.

No one ever had more reason to feel that their property was secure from fire than had the managers of the Cocheco Manufacturing Co. to feel that their No. 1 mill was immune. Repeated inspection by the Mutual Insurance Companies had reported the mill and its equipment as "excellent." Aside from the corporation's own equipment, there was a very efficient city department, with its central station within a few hundred yards, with two fire engines, and what was supposed to be an unlimited supply of hose.

When darkness came on Saturday night, the upper floor, with its machinery, had fallen and in the mass of woodwork and machinery the fire played back and forth in spite of many streams of water, at times more than twenty, which were constantly played against it. There is a limit to human endurance, and by this time we find this limit reached in the case of many of the men, who through the long day, with the thermometer at no time above zero, had toiled against the tremendous odds. These men were by necessity temporarily relieved, while the rest of them worked steadily through the long winter night. Sunday morning came and found conditions not materially changed, excepting that the fourth floor had fallen to the third floor, and the third unable to withstand the load, weakened by its charred beams, had late in the night given out for some distance along the centre of the mill. There was at this time no great mass of fire, but innumerable small ones, mostly in the double beams. Sunday night came, finding the fire so far under control that the corporation fire pumps, after a record breaking duty, were shut down. All Sunday night however, several streams were in constant use and at one time it was thought that a genenal alarm would have to be rung in again owing to the starting of the fire among the wreckage. Monday morning the view inside the mills can be neither imagined not described.

In his comments on the lessons taught by this fire, Mr. Fish stated that each individual mill, where it is possible, should be controlled by one main valve, situated well outside of the building and marked plainly with an indicator post. No underground valves, marked or unmarked, requiring a wrench should be allowed. Inside of the building, each floor, or each section, dividing as it seems best, should be controlled by its own valve located outside of that department, preferably in the hallways. The location of these department valves is most important. There is the one objection to locating them within easy reach that they may be tampered with by unauthorized persons. Again, there is the serious objection to locating them out of reach so that a ladder or steps of some kind are required. Again, it is a mistake to locate these valves where the steps or ladder used as a means of getting at them come in direct route of the people coming out of the mill.

At the time of the Cocheco fire, the main shut-off valve, shutting off one-third of the entire mill, as explained, was located in the lower hallway, at a convenient height from the floor, where it could be handled readily without the use of steps. At the first alarm of fire the crowds of operatives, who hastened down the stairways and out through this hall, interfered seriously with the two men who were opening the valve. The plan which has been adopted in the new mill locates these valves high up, out of the way, and an iron walkway is constructed and permanently fastened under these valves, at a convenient height for operating them, this walkway being reached from the floor by an iron stairway located in the hallway outside of the course of travel.

All inside valves should be outside screw and yoke, or so called rising stem, valves, discarding entirely the ordinary form of gate valve, which you can never be sure of as being open or shut without trying it, and then we may run into the most annoying uncertainties caused by the occasional introduction of a valve of the opposite hand. The left hand valve is certainly an invention of the Evil One.

The running of main belts from the engine room up through a mill building, no matter whether it be at the centre of the building or at the end, is without doubt bad practice, speaking from the question of fire protection, according to Mr. Fish. The rapidity with which fire will travel, up and down, through belt boxes, is surprising. At the Cocheco fire, the engine room had fire in it a very few moments after it was discovered in the card room three stories above. The rapid spread of the fire from room to room was without doubt due to a great extent to the openings in wall and floors, made necessary for the passage of the main belts. Construct the belt tower wherever it seems best, Mr. Fish advises, but build it fireproof and have it entirely cut off from the rest of the building. There should be no openings from the engine room through which a fire might pass into the mill.

Tinned fire doors are almost perfect protection against the spread of a fire. At the Cocheco fire not a single door failed to do its duty. They will get out of repair, as regards the running parts, usually the morning the inspector arrives, but otherwise than this they are most satisfactory. An ordinary sheathing partition, supplemented by a stream of water, is a valuable fire retardent. A temporary partition across the end of the card room stopped the spread of the fire in that direction.

It seems to be general practice to use for a column cap on which the floor beams rest, a cast iron plate of considerable length. In the Cocheco No. 1 mill these plates were 24 in. long and about 14 in. wide, the width of the beams. The overloading of the floorbeams on the lower floors by the wreckage and ice, deflected them to such an extent that a great weight was brought on the ends of the plates and many of them were broken. There certainly can be no reason, according to Mr. Fish, why a long plate should be used as it can add nothing to the strength of the building. A column cap, he states, should be only sufficiently long to cover the column or post with enough additional length for the lag screws or bolts holding the timber. These caps in the Cocheco mill were fractured square across the center, or directly over the center of the column. They were of good design, being about 2 in. thick on the ribs.

There is nothing to be said against the wooden column, according to Mr. Fish, and in case of fire, he believes it is much safer than the iron column. The wooden column chars easily but burns away slowly. The floors fall a long time before posts have become sufficiently charred to weaken them materially.

Mr. Fish found it to be impossible to describe briefly the difficulties encountered during the Cocheco fire on account of the double beams. A picture of one of them was printed in this Journal on March 9, 1907. The open spaces between the two timbers formed a safe retreat for the fire and also furnished a ready means of travel from one side of the room to the other, or in a number of cases, through the medium of the posts the fire would travel from floor to floor, as well as from side to side. A number of times fire started in the double beams on the lower floor, in spite of the fact that there was 1 to 3 ft. of ice and water on the floor above. Time after time did it become necessary to send men into the lower parts of the building with fire extinguishers to put out these small fires, which would appear in the double beams in most unexpected locations. It took 48 hours of constant attention with chemical extinguishers and small hose streams to save that part of the floor in the ell which was over the main engines, and in spite of this it became necessary to shore up under the beams, they had become so honeycombed. In a number of cases the beams were burned away, always from the inside, out, until what was left fell of its own weight leaving the floor above practically intact with the floor spikes sticking through it.

It was practically impossible to extinguish fire in the beams, without getting under it so that the stream could be directed squarely into the open space. From any location except directly beneath, the stream of water, no matter how powerful, had little or no effect as it could not get at the fire. It is readily understood why these beams, when greatly overloaded with ice and water and the wreckage from above, could stand but little of such treatment before they gave way. During the progress of the fire these beams broke down continually, making work inside of the building extremely dangerous. Some practical means should be devised for remedying the evils of double beams in part at least.

At Cocheco Mr. Fish is now experimenting with the filling of the space with a cheap grade of common cement. A batten strip is first nailed along covering the opening on the under side of the beam and then the space is filled with cement grout, poured down through holes bored in the floor above. This is a rather slow and laborious process, necessitating the boring of many holes through the floors. The fastening or dogging of floorbeams to the brick walls is also to be avoided. It is remarkable fact that although every beam in No. 1 mill was securely fastened to the walls by irons imbedded in the brickwork, in every case the beam in falling either pulled the iron clear from the beam, or tore the fastening away from the brickwork without doing material damage to the walls themselves.

The fact that the brick walls stood so well goes to prove conclusively, Mr. Fish believes, that this mill broke down rather than burned down. There was of course a large area of fire, which, augmented by the extreme cold weather, proved most stubborn, but at no time after the first rush of the flames through the rooms was the heat intense. Had this mill been constructed of solid beams, the loss would have been without doubt comparatively small.

The Pennsylvania Railroad Improvements at Blairsville, Pa.

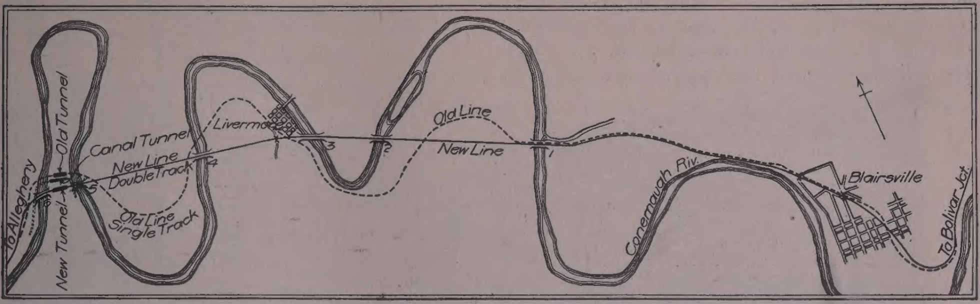
By G. W. Philips, Engineer in Charge, and J. Gwilliam.

The Pennsylvania Railroad Co. in pursuance of its long-established policy of reducing grades and curvature wherever possible, is constructing a change of line about 9 miles long on the Conemaugh Division, from Blairsville to Tunnelton, Pa., at an expenditure of about $2,500,000, which will complete the last stretch of double track from Allegheny to Johnstown, Pa., a distance of 95 miles, with a compensated grade of 0.3 per cent. eastbound, or against loaded traffic, and which will enable this division to take care of all freight originating on it, and also that originating at and west of Pittsburg; thereby relieving the congested main line and at a very considerable less cost for haulage.

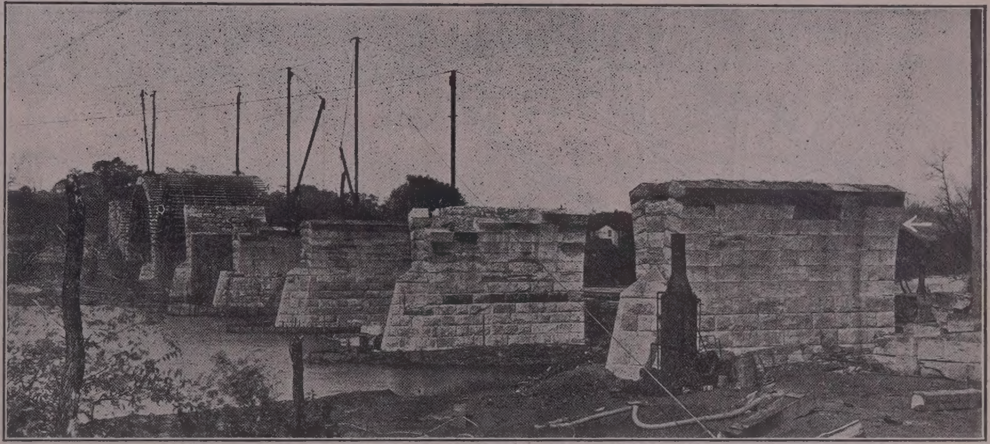
The work, one of the largest single undertakings on behalf of this company, was under the general supervision and direction of Mr. A. C. Shand, chief engineer of the Pennsylvania R. R., assisted by Mr. E. B. Temple, assistant chief engineer and Mr. J. F. Murray, assistant to the chief engineer. The immediate work on the ground was done by Mr. C. S. d'Invilliers, engineer of construction, and Mr. G. W. Philips, engineer in charge.

The new line starts 1½ miles east of Blairsville and runs nearly parallel to the old line, but is depressed about 25 ft. until it reaches the eastern end of Blairsville, where it crosses under the old tracks by way of a concrete jump-under for a distance of 877 ft. Emerging therefrom, it finally parallels the old line again just west of Blairsville for a distance of 2 miles, or to Social Hall Station. It there leaves the old line and for 4 miles is a most decided change from the old alignment. The distance from Social Hall Station to the end of the single-track on the old line is 28,478 ft., consuming 777 deg. 37 min. of curvature and having a very un-uniform grade; while the distance on the new line is 21,400 ft, and has but two curves; one, a 30-min., consuming 15 deg. 33 min. and the other a 4 deg., consuming 65 deg. 22 min., a total of 80 deg. 55 min.; thereby shortening the line by 7,078 ft. and eliminating 696 deg. 42 min. of curvature.

This change, of which about 95 per cent. is now completed, necessitated the moving of 2,000,000 cu. yd. of excavation, building 110,000 cu. yd. of masonry, a tunnel 760 ft. long, besides the necessary amount of track-laying, ditching, sodding, depression of streets, encountering the difficulties of sewer, gas and water pipes, eliminating grade-

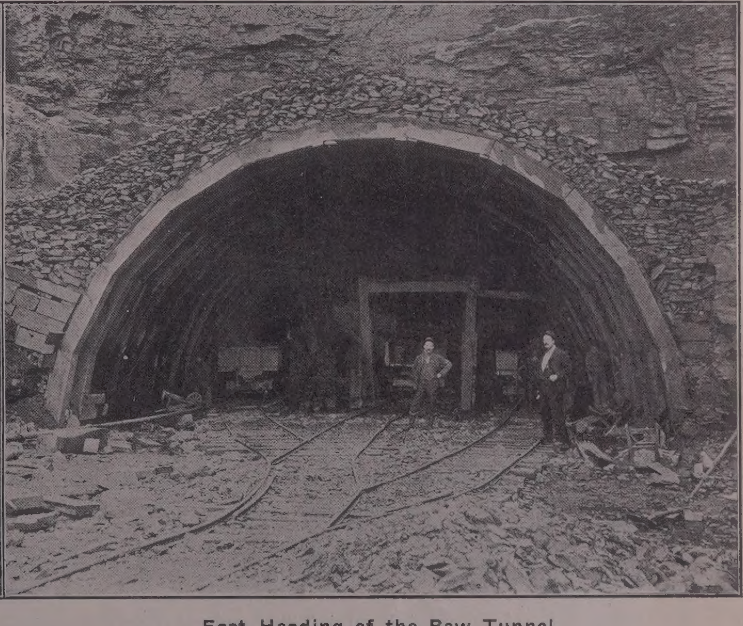


New and Old Lines of Pennsylvania R. R., Blairsville to Tunnelton.



Bridge Three before Turning the Arches.

Jumpunder before Removal of Core.



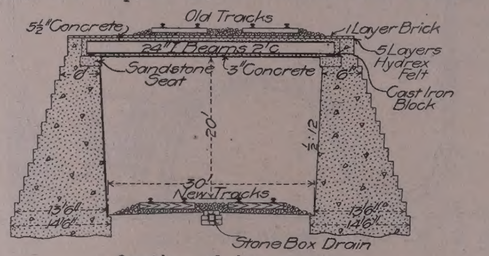
East Heading of the Bow Tunnel.

crossings in townships, vacating and supplying streets in the Borough of Blairsville, which has a population of 6,500, and also in Livermore borough, and securing the consent of these municipalities for the improvements contemplated.

The work is divided into six sections, starting from the eastern end of the line, as follows:

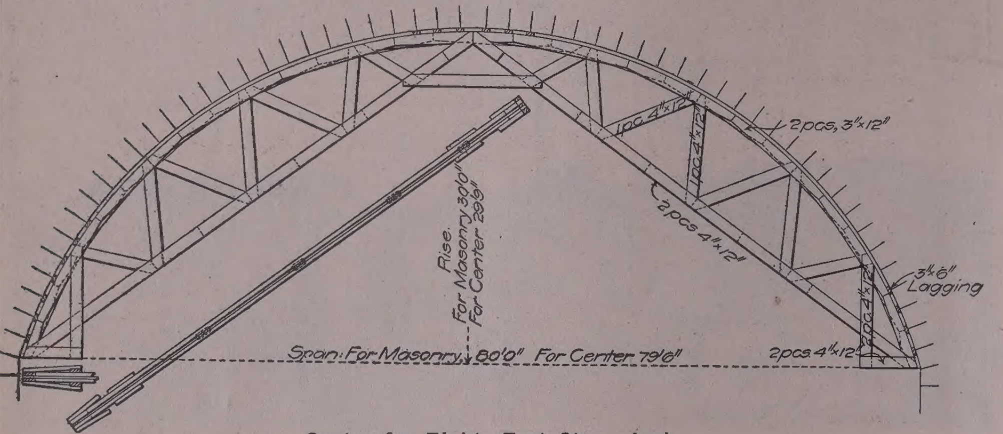
Blairsville section, including work through Blairsville, or from Sta. — 10 to Sta. +100, which work was contracted for by H. S. Kerbaugh, Inc., of Philadelphia, consisting of about 300,000 cu. yd. of excavation, 15,000 cu. yd. of concrete and about 10,000 cu. yd. of bridge and retaining wall masonry. At the eastern end of this section is located what is locally known as the "Alum Bank." The rock here, which is of an alum formation and is broken off at an angle of about 75 deg., was continually slipping, causing the fill which was made outside of it to slide; at times settling over 15 ft. in one night. The filling of cinder and earth has been kept up until now it is the belief of the engineers that this slipping has been mastered.

Going west from this slide there is an approach cut 3,500 ft. long, containing 150,000 cu. yd. of excavation, all of the material being used at the slide above mentioned. From this approach cut the new line crosses under the Indiana Branch tracks and Market St., Blairsville, at Sta. 58, by a reinforced concrete subway, or jumpunder, which is about 877 ft. long. During the construction of this subway, a very novel method of supporting the two tracks at this point was employed. First, one hundred 12x12-in. white pine piles, 20 ft. long, spaced 8 ft. apart, were driven twenty-five alongside of each rail. The excavation was then started and carried down to a depth of 5 ft.; there the piles were sawed off enough to allow a cap and two 8x14-in. by 16-ft. timbers, placed on edge, side by side, to rest on top. This, of course, was done only in short sections of about 16 ft. until all the piles carried the tracks; then the excavation was carried on and completed without further blocking until the bottom of the piles was reached. From there to the bottom of foundation, a distance of about 10 ft., the excavation was very quickly blocked and wedged. When the concrete walls were started, the piles were left in place and the concrete built around them, leaving them in the wall. The roof of the jumpunder is also built of concrete, reinforced with 131 2-ft. I-beams, spaced 2 ft. apart. All water and gas pipes encountered were carried across between these I-beams and concreted over. A typical cross-section of the side walls and roof is shown herewith. Each side wall was built independent of the other, then the covering was laid and lastly the excavation in the core was taken out by a model 20 Marion steam shovel. The concrete used was mixed in a proportion of 1:3:5.

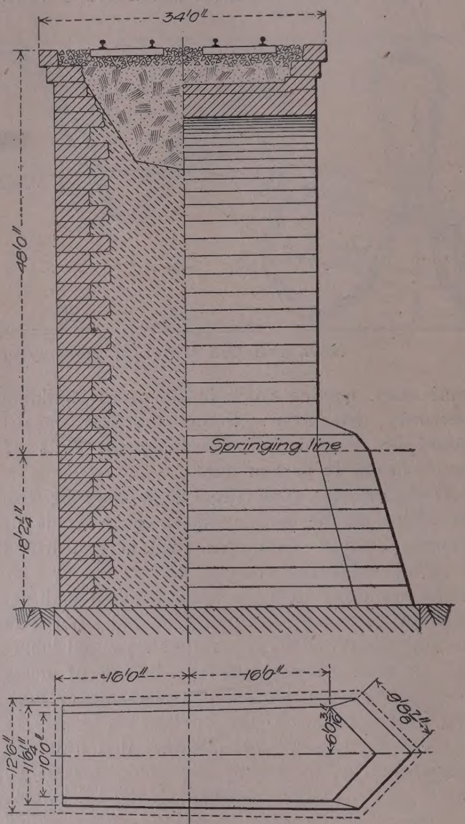


Section of Jumpunder.

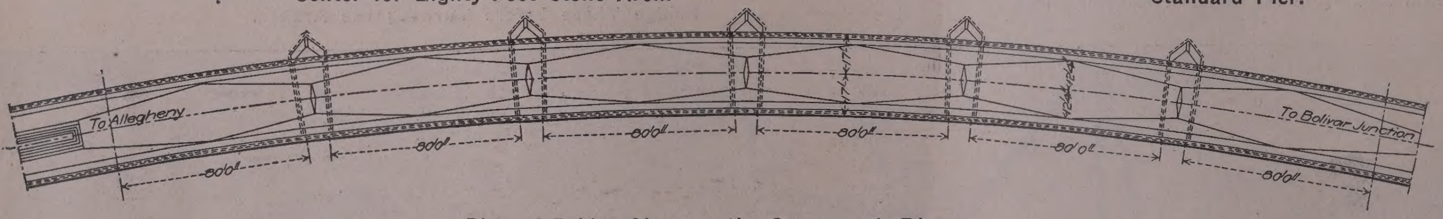
As the new line practically divides the town by a 25-ft. cut, it was found necessary to build a new sewerage system for the east side; thereby greatly benefiting that portion of the town. The new sewer is over 2,000 ft. long and 3 ft. in diameter. At Sta. 74 on the west side of Blairsville, the line crosses Walnut St. at about the original street level at an angle of 45 deg. This necessitated the depression of the street about 12 ft., including sewer, gas and water pipes, and electric wires, and at the same time keeping all the residences connected with them; building new abutments for a through-girder solid-floor undergrade bridge of 83-ft. span, and moving back the east abutment of the old undergrade bridge under traffic, which at this point meant keeping up four tracks. Retaining walls of block rubble masonry were built on both sides of the street. sandstone stairways lead from each house to the



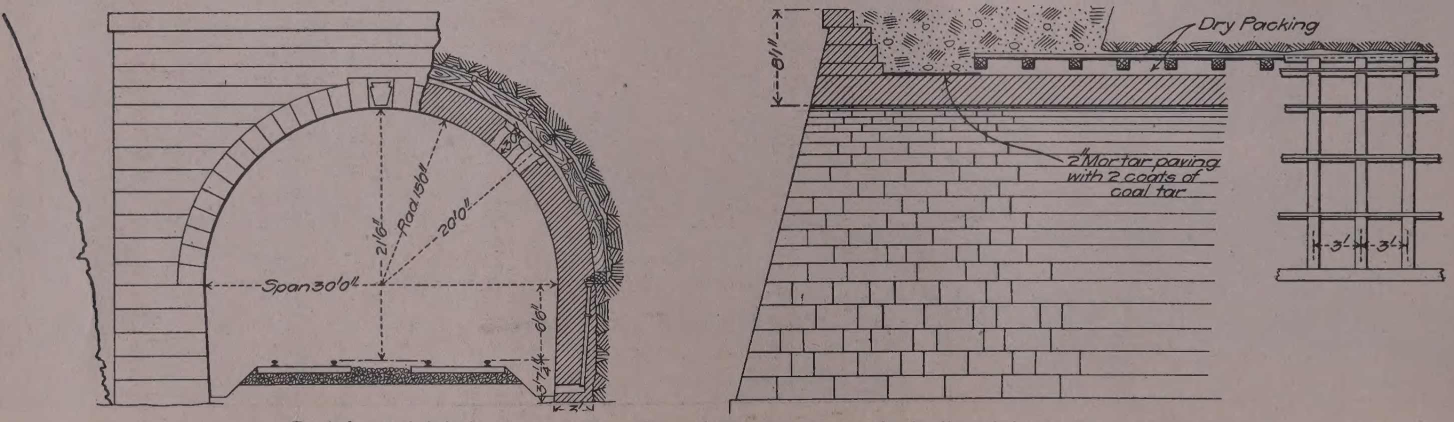
Center for Eighty-Foot Stone Arch.



Standard Pier.

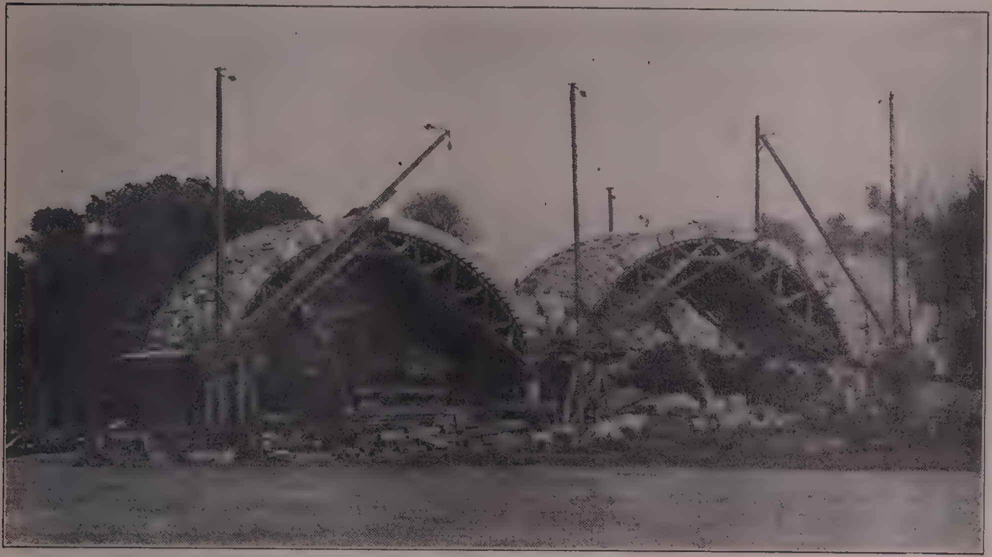


Plan of Bridge Six over the Conemaugh River.



Portals and Timbering of Bow Tunnel on Pennsylvania Railroad Improvements.

pavement, driveways from the street to the rear of residences, lawns have been terraced and sodded, and as a final touch, a substantial wrought iron railing run along the top of each wall, resulting in a marked improvement as compared with the original street, despite the usual fears of the property owners.



Two Arches of Bridge Four.

At Sta. 96, an overhead highway through-girder bridge of 122-ft. span with two abutments and one pier, containing 2,273 cu. yd. of masonry, crosses both the new double track and four yard tracks; thereby opening a new street for the Blairsville Borough and giving them an additional crossing.

Section 1. Sta. 100 is the end of the Blairsville section and the beginning of Section 1. From Sta. 100 to Sta. 180, there were 160,000 cu, yd. of excavation. An overhead highway truss bridge crosses the new double track at Sta. 140 by a 120-ft. span. In this bridge there are two abutments, containing 785 cu. yd. of masonry.

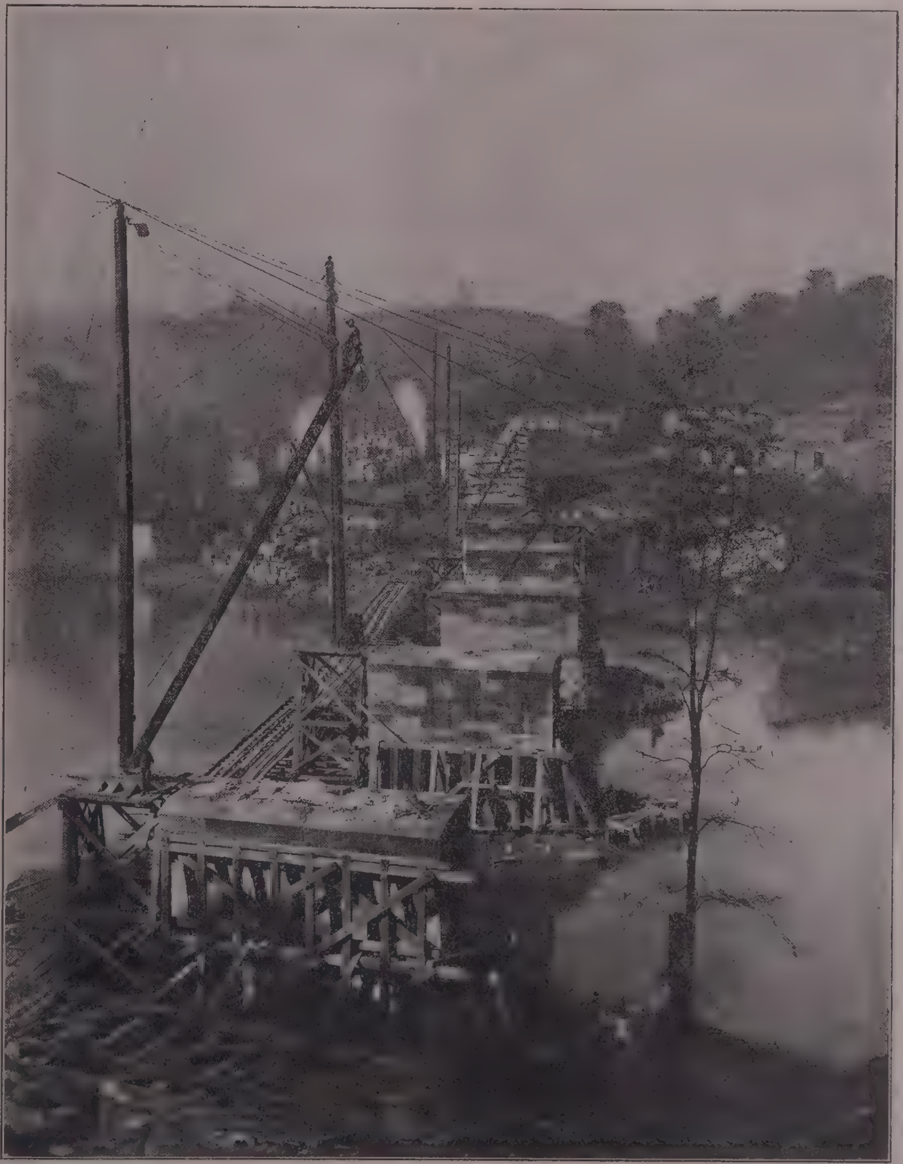
At Sta. 195 a single-track deck truss bridge on the old line crossed the Conemaugh River 75 ft. above mean water. The new line at this point is parallel to the old and 15 ft. to the south of it. The extension of this bridge for the additional track is made up of four 137-ft. spans. The three piers are 53 ft. high, 14 ft. wide and 45 ft. long, built at an angle of 80 deg. with the center line. The extension of the masonry was made on the up-stream side and consisted simply of extending the piers about 18 ft. and building wings to the original U-type abutments. This latter was made very difficult by reason of the old abutments, in that the wing walls were built plumb from directly under the ends of the cross-ties for a depth of 84 ft. through very soft material to rock, to which depth the new masonry was also carried. The possibility of these walls collapsing was very apparent; this was overcome, however, by building the end of the wing walls of the new abutment first, against which the old walls were well braced by 12x12-in. timbers. These were placed as fast as the excavation progressed and were afterward removed as the masonry was built. There were 6,300 cu. yd. of masonry built and the bridge was completed in six months.

An overhead highway truss bridge crosses the new line at Sta. 201 by a 95-ft. span. There are two abutments in this bridge, containing 795 cu. yd. of masonry.

From Sta. 200 to 240, there were 355,000 cu. yd. of excavation which was used in the fill from Sta. 240 to Sta. 260 which marks the end of Section No. 1. C. A. Sims & Co., of Philadelphia, had the contract for this section.

Section 2.—Sta. 260 is the eastern end of Section 2, and at this point bridge 2 crosses the Conemaugh River, which is a stone arch bridge 740 ft. long, comprising seven arches of 80 ft. span, 40 ft. rise, six piers, 10 ft. wide, 22 ft. high and 42 ft. long, and two abutments 60 ft. long. The coping sets 70 ft. above the top of the foundation.

To save building larger centers, seven courses of ringstones and sheeting were set by templets and the centers erected from there up, instead of from the springing line. There were 20,790 cu yd. of masonry built and completed in ten months. Several damaging floods necessitated the suspension of work on this as well as all the other bridges on this work. The arrow on pier 1 of an accompanying illustration shows to what height the last flood reached.



Bridge Six with Seven Courses of Sheeting Set.

Leaving bridge 2, the line crosses a low flat 1,800 ft. long, requiring a fill 50 ft. high and 66 ft. wide, containing about 450,000 cu. yd. Sta. 278 is the end of the fill and also the east abutment of bridge 3. This bridge is 770 ft. long and built on a 30-minute curve. It is 34 ft. outside to outside of coping, which sets 66 ft. above the top of the foundation. There are seven arches of 80 ft. span and 40 ft. rise, six coffin-shaped piers, 9 ft. 10 in. wide at the shoulder and 10 ft. 1½ in. wide at the downstream end, and 18 ft. high, and two abutments 75 ft. long. The centers were erected as those on bridge 2. This bridge was completed in seven months and contains 20,680 cu. yd. of masonry.

At Sta. 293 a new passenger station was built to replace the old Livermore station. The Vipond Construction Co., of Altoona, were the contractors.

An overhead highway truss bridge crosses the new line at Sta. 295 with a span of 95 ft. There are two abutments in this bridge, containing 640 cu. yd. of masonry. From Sta. 290 to Sta. 321, which is the end of section 2, there were 270,000 cu. yd. of excavation and 80,000 cu. yd. of embankment. H. S. Kerbaugh, Inc., of Philadelphia, was the contractor on section 2.

Section 3.—At Sta. 321, which is the beginning of Section 3, bridge 4 crosses the river at a height of 62 ft. The bridge is 630 ft. in length and has seven arches of 80 ft. span and 30 ft. rise, with a radius of 41.67 ft., five piers 10 ft. wide at the springing line and 24 ft. high, and two abutments 40 ft. and 60 ft. in length. The centers for this bridge were started at the springing line of the arch and set on an average, 0.18 ft. high to allow for settlement. The bridge was completed in nine months and contains 14,425 cu. yd. of masonry.

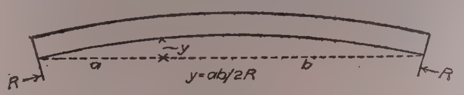
From Sta. 327 to Sta. 365, there were 600,000 cu. yd. of excavation. About one-half of this material was wasted and the other half hauled 1½ miles east to the fill between bridges 2 and 3.

Bridge 5 crosses the Conemaugh River at Sta. 267, and is 512 ft. long, 60 ft. high and has five arches with a clear span of 80 ft. and a rise of 30 ft. The four piers and two abutments were all built on solid sandstone. The centers used were erected as those on bridge 4; provision was made for settlement by setting them 0.2 ft. high, which, after the arch was turned, brought the crown to the correct elevation. The bridge was completed in six months and contains 10,620 cu. yd. of masonry.

Section 5.—About 100 ft. west of bridge 5 is the east portal of the Bow tunnel which is 760 ft. long and timbered throughout, using the block system. It was driven through a hard, slaty shale, which disintegrates rapidly upon exposure to the elements. The heading, which was 40 ft. wide, 19 ft. high and ran about 22 cu. yd. per linear foot, was put through by first driving three drifts about 6 ft. square, one on each side at the springing line and the other at the roof in the center. After these had progressed enough to allow one set of wall plates, 12x12 in. by 16 ft. to go in the side drifts, the erection of the 12x12-in. white oak segments and 3-in. lagging was begun from the inside and worked back toward the face, which was repeated for every wall plate set. It was found expedient to do this on account of the unsafe character of the material overhead. Timbering it thus, there was never any danger of a serious cave-in. The heading was driven and timbered in six months. The bench, running about 12 cu. yd. per linear foot, was taken out in two months by a 45-ton Marion steam shovel, operated by compressed air at a pressure of 80 lb. per square inch. The portals were built of a fine-grained, white, local sandstone, the face having a batter of 3 in. per foot. The arch and bench walls were built of block rubble masonry, the arch being turned in 30 ft. sections. The entire tunnel was lined with rubble masonry in four months. The heading was started Aug. 16, 1906, and the masonry completed Aug. 30, 1907. McMenamin & Sims, of Philadelphia, were the contractors on this tunnel, which constitutes Section 5. The fact of this Tunnel being entirely lined with rubble masonry makes it unique among Pennsylvania Railroad tunnels. The work was completed without any accidents of any moment.

Section 4.—The east abutment of bridge 6 is 130 ft. from the west portal of the Bow Tunnel. This bridge is 591 ft. long, built on a 4 deg. curve and consists of six arches of 80 ft. span, 40 ft. rise, two abutments 16 ft. and 60 ft. long, five coffin-shaped piers 12 ft. 1 in. wide at the shoulder and 10 ft. wide at the downstream end. The coping is 60 ft. above low water. The centers used in this bridge were those used on bridge 5, simply changing the small strips around the edge, which had been cut to a 41.57 ft. radius, and replacing them with ones having a 40-ft. radius, and then shortening the brace between the two long chords. They were then erected, as were those used on bridges 2 and 3, by starting them at the top of the seventh ringstone.

A short description may here be admissible of the method used in giving the line for this bridge. The center lines of the piers are on radial lines at the center line of the bridge. These radial lines were all referenced, as were also the tangents to the curve at those points. Thus the intersection of those two lines was the center of the pier and the center of the abutments at the springing line, from which the center line could be produced quickly at any time, using the referenced tangents as back-sights. In giving the side lines over the centers, a thin steel wire, marked every 10 ft. with a small piece of white string, was stretched from pier to pier at the ends and then, by plumbing down to one of these marks and measuring off the previously figured side ordinate, the exact side line was established. The lines for the parapet walls in the valleys between the arches was also given by side ordinates, but by a little different method. The distance was measured where the line was needed, which grew greater every course, and the ordinates were figured by the following diagrammatic formula:



Then by stretching the steel tape, the line was marked off. This was a rough but practical and very quick way of keeping the masons on line. The accuracy of the methods used was proved by running parallel lines across the bridge after the entire coping was laid and at no place was the coping found to be one-half inch out of line This bridge was completed in nine months and contains 14,212 cu. yd. of masonry. Bridges 1, 2, 3, 4, 5 and 6 comprise Section 4, for which C. A. Sims & Co., of Philadelphia, were the contractors.

In turning all the arches for these bridges, each arch was completely turned from pier to pier and the haunching started before the centers for the next arch were set. In one case four consecutive arches were turned from one abutment toward the other and stood for one month with no support between the last arch and the next pier. This method gave the piers a rigid test, especially where the rise was 30 ft. and span 80 ft., but in no case did a pier show any signs of weakness, which fully justified their design.

From bridge 6 to Sta. 410 there were 35,000 cu. yd. of excavation, which completes the change of line, the new tracks joining the old ones at this point, which is also the end of Section 3. C. A. Sims & Co., of Philadelphia, removed one-half the excavation and McMenamin & Sims, of Philadelphia, completed it.

The Operation of the Winnipeg Water Softening Plant.

The water softening plant at Winnipeg, Manitoba, recommended by Dr. Rudolph Hering in 1897, was built by the Pittsburg Testing Laboratory and put in operation in July, 1901, being the first large municipal water softening plant in America. It was described in The Engineering Record of June 14, 1902. The process followed consists of adding lime to the water, followed by the precipitation of the sludge in tanks, filtration through cloth filter-presses, and subsequent carbonation of the effluent with the products of combustion of burning coke. The operation of the plant was recently investigated by Messrs. James H. Fuertes, R. S. Lea, J. E. Schwitzer and George C. Whipple, the board of consulting engineers who have been examining methods of securing a new supply for the city, and from their report the following statements regarding the operation of the plant have been taken.

The softening process is limited to the removal of the carbonates of lime and magnesia and no attempt is made to remove the sulphates. The analyses which have been made indicate that the efficiency of the plant has been reasonably satisfactory in accomplishing the work for which it was designed, though it has not by any means completely softened the water. The efficiency of the plant in removing the total hardness is about 56 per cent. and the temporary hardness 75 per cent., while the permanent hardness and chlorine remain unchanged. The magnesium is reduced by about 46 per cent.

The well water contains but little iron, all of which is removed during the softening process, and between 20 and 30 parts per million of free carbonic acid, but no information was available to show the amount of carbonic acid left in the water after treatment. Without the use of the coke-burning apparatus the water would be free from carbonic acid and would have a slight alkalinity due to the presence of normal carbonates. With the coke-burning process in use, regulated to supply just the right amount of carbonic acid, these normal carbonates would be changed to soluble bicarbonates with no excess of carbonic acid; but if not properly operated there may be supplied to the water an excess of carbonic acid fully as large as that present in the well water before treatment.

The figures in the accompanying table show the average quantities of chemicals used in the softening process.

AVERAGE QUANTITIES OF CHEMICALS USED FOR SOFTENING.

Year	1903	1904	1905	1906	1907*
Water softened daily, million imperial gallons	1.54	1.79	2.19	2.36	2.33
Lime, pounds used per day	5,219	5,686	7,223	7,797	8,067
Coke, pounds used per day	875	894	755	620	555
Acid, pounds used per day	45	61	67	65	61
Lime, pounds per million imperial gallons	3,390	3,180	3,300	3,300	3,465
Coke, pounds per million imperial gallons	569	498	345	263	237
Acid, pounds per million imperial gallons	29.2	34.1	30.6	27.5	26.2

*For five months only.

These figures show that during the last five years there have been required for softening an average of 3,327 lb. of lime per million imperial gallons, 382 lb. of coke for changing the normal carbonates to bicarbonates, and 29.3 lb. of acid for cleaning the cloths used in the filter presses. The cost of these chemicals has been as follows:

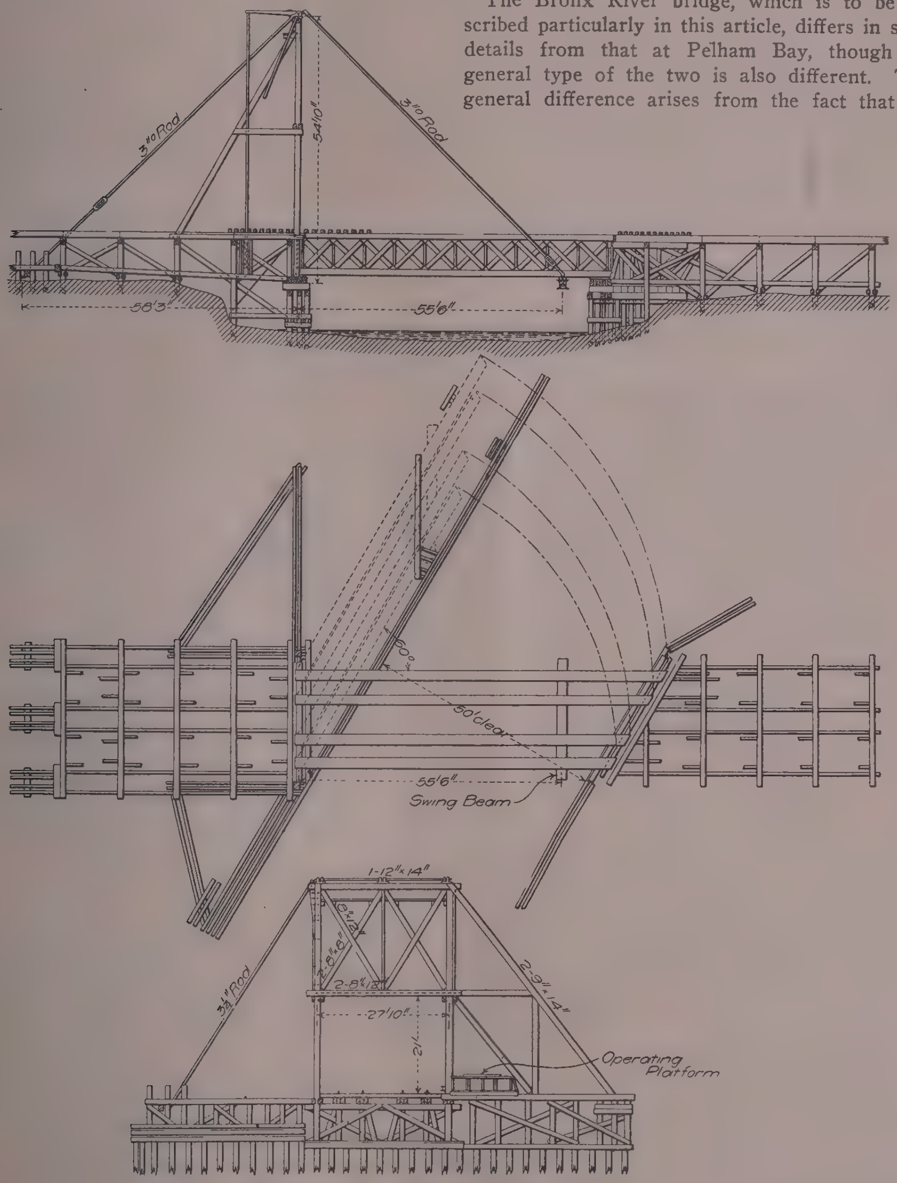
Lime, 3,327 lb. at 0.63 cent	$20.95
Coke, 382 lb. at 0.15 cent	1.91
Acid, 29.3 lb. at 1.5 cent	0.44
Total	$23.30

According to the report, the softening plant does not now appear to be in first-class physical condition, although it is operated in a fairly satisfactory manner and gives as good results as could reasonably be expected. The plant reduces the hardness of the water from 480 to 210.

NEW RAILROAD CONSTRUCTION in 1907 amounted to 5,212 miles, according to the "Railroad Gazette." This includes 14 miles of new main track railroad, but no second, third or fourth tracks, sidings or electric lines. The total is 7½ per cent. less than the total of 1906. The longest single line built is the Portland & Seattle, 220 miles, owned jointly by the Great Northern and the Northern Pacific. The Western Pacific Ry. has 263 miles completed now, leaving 577 miles to be finished. Ninety miles of new track were laid in Alaska. The largest mileage in any one State was 384 miles in Louisiana, but Texas, South Dakota and Washington were not far behind. The same journal gives the output of cars from car builders as 289,645, of which 5,457 were passenger cars; these figures do not include the cars built by the railways nor those for electric surface lines. There were 6,564 locomotives built for domestic use and 798 for export, exclusive of those built by the railways.

Temporary Jackknife Drawbridge over Bronx River on the New York, New Haven & Hartford R. R.

The New York, New Haven & Hartford R. R. is at the present time using two jackknife bridges for temporary crossings over Bronx River and Pelham Bay on the reconstruction and six-tracking of the Harlem River Branch, a full description of which work was published in The Engineering Record of November 9, 1907. A bridge of this type was in use at Bronx River prior to 1893, when it was replaced by the four-track swing bridge, which was removed to make way for the six-track Scherzer lift bridge now under construction. This type has found most favor in New England, where the clear channel span between fenders was generally 35 to 40 ft. while the one at Bronx River has a clear channel of 50 ft. Such bridges have also been used before by this railroad for temporary purposes, more recently at Westport and Cos Cob, Conn., the bridge now at Pelham Bay being the same one formerly in place at Westport. On account of its simplicity, ease of operation and of erection, the type, even under heavy engine loadings, has given general satisfaction.



Jackknife Drawbridge, with Skewed Channel, at Bronx River.

The bridge consists of four trusses swinging in a horizontal plane, and carried by suspension rods running to the top of a gallows frame. The latter is braced with back and side stay rods and stiff legs, and carries on its top the shafting for lifting the trusses preparatory to swinging the bridge. The trusses, which are each separately pivoted on the bridge seat beneath the gallows frame, are carried on a swing beam, which is pivoted to the lower chords near their outer ends, and to it the suspension rods are attached. The rods at the top of the gallows frame are secured to mechanism which allows the swinging end of the trusses to be raised from ¾ to 1 in. so as to clear the rail chairs. When the bridge spans the channel the trusses are spaced the same as the rails for double track. They remain parallel in swinging and when in the open position are but a few inches apart.

The Bronx River bridge, which is to be described particularly in this article, differs in some details from that at Pelham Bay, though the general type of the two is also different. This general difference arises from the fact that the channel in the case of the former bridge is at an acute angle with the center line of the railroad, whereas in the latter bridge the channel and the center line form a right angle. This gives rise to quite a different layout as far as the plan is concerned, but makes no essential variation. The accompanying diagrams show the difference of the two plans. With a square channel opening, such as is found at Pelham Bay, the gallows frame is skewed to the track and because of its consequently greater span makes it more difficult to secure a rigid, structure than where the gallows frame makes a right angle with the railroad center line. Another advantage of the skew channel is the fact that the angle of rotation of the trusses is but 60 deg., whereas with the other type the angle is 90 deg. All of the jackknife draw bridges thus far used by the New York, New Haven & Hartford R. R. have been of these two types, with the channel making an angle of either 60 or 90 deg. with the center line of the track.

The bridge at Bronx River has a clear span between fenders of 50 ft., which is greater than those of the other bridges referred to. The trusses evidently are all of different lengths, the longest 76 ft. 1½ in. between centers of bearings and the shortest 65 ft. 5 5/16 in. The structure was designed for the standard New Haven loading consisting of two engines, as shown in an accompanying diagram, followed by a uniform load of 5,000 lb. per linear foot. The procedure in opening the bridge after securing permission from the signal tower by the withdrawal of the locking plugs is to drive back the locking wedges so as to clear the rails on the draw, then raise the swinging end of the trusses by means of the lifting mechanism so as to clear the rail chairs, and finally to swing the trusses. Manual power is used both for lifting and swinging.

The structure is built on pile bents, twelve on the pivot and seven on the rest end. Five of these bents on each side of the channel, however, are merely the continuation of the bents of the trestle in which the structure is located, with some additional longitudinal diagonal bracing. The remaining bents, however, are specially placed to carry the structure and extend out considerably on each side beyond the limits of the two-track trestle. A fender bent is placed on each side of the channel. Some additional piling was necessary, in addition to that in the bents, for the anchorages of the back stay rods running down from the top of the gallows frame, and to form a stop to prevent the trusses from swinging too far back when the bridge is opened. The total number of piles used on the pivot end including all the piles in and between the fenders and the anchorages of the back stay rods is 186, and the number in the rest end including the fender and the five bents of the regular trestle which have special longitudinal diagonal bracing is 94.

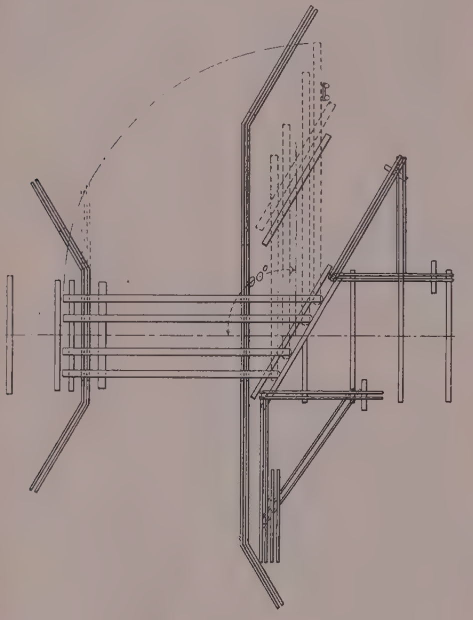
The gallows frame has a height above the base of rail of about 45 ft., the clearance above the base of rail being 21 ft., and the depth of the bracing 22 ft. 7¾ in.

The clear span across the two tracks is 26½ ft. The lower horizontal member of the gallows frame truss consists of two 8 x 12-in. timbers and the upper horizontal members of one 12 x 14-in. timber. The posts are 14 x 16-in. sticks 54 ft. long, running down beneath the track level about 10 ft. Two 8 x 8-in. members and one 8 x 12-in. are used for the diagonals in each panel of the gallows frame truss, and the center tension member is composed of two 1-in. steel rods. A 1⅜-in. rod runs through the lower chord. In order to prevent the stiff leg pushing up the top chord, a 1⅜-in. rod has been placed beside the post, passing through the bottom chord and fastened with a nut bearing against a heavy cast iron washer.

Swaying of the gallows frame at right angles with the track is prevented by a stiff leg on the side to which the trusses swing when the bridge is open, and by a tension rod on the other, the reasons for this design being evident from an examination of the stresses coming on the gallows frame when the bridge is open. The strut on the compression side is made of two 9 x 14-in. timbers and, midway in its length of 59 ft., is braced by two 12 x 12-in. members, one horizontal and tied to the gallows frame, and the other vertical, attached at its bottom to one of the bents. A 12 x 12-in. diagonal runs between the ends of these two 12 x 12-in. braces. The tension rod is 3¼ in. in diameter and connects at its lower end by means of the 16 x 16-in. oak block with the cap of the bent lying directly beneath it. The compression coming upon this cap is transmitted through two 8 x 12-in.

horizontal timbers to the gallows frame, against which it butts with a specially designed cast-iron cap.

The swaying of the gallows frame in a direction parallel with the tracks is prevented by three back stay rods 3 in. in diameter running back to anchorages and by two stiff-leg braces one on each side of the tracks. The anchorages for the three back-stay rods each consist of six piles tied together by 8 x 12-in. timbers 9 ft. long, which butt against 16 x 16-in. blocks, bearing against the fifth or last of the trestle bents which are cross-braced so as to take up the stresses in the bridge. The rods take bearing beneath a 16 x 16-in. oak block fastened to the two center piles of each anchorage beneath the 8 x 12-in. braces. The diagonal stiff-leg brace on each side of the track consists of a 12 x 14-in. stick braced at the center by two horizontal 6 x 12-in. planks running to the post of the gallows frame and connected to the latter immediately below the lower member of its truss. The bottom end of the stiff-leg is tied to the gallows frame post at the level of the track by two 8 x 12-in. timbers.



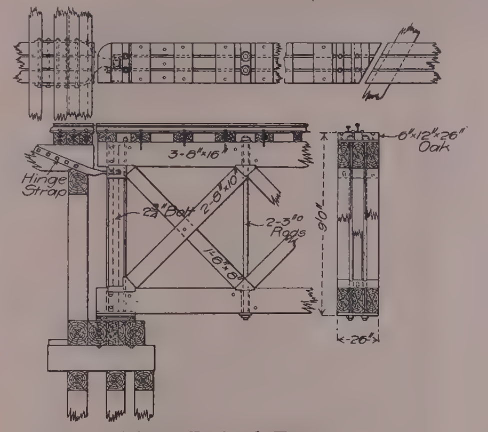
Square Channel Type.

In designing the anchorages for the back stay rods, no reliance whatever is placed upon pile friction. The maximum upward pressure was figured and the anchorages weighted down with old rails.

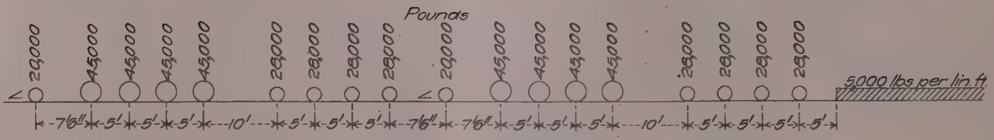
The lifting of the free end of the bridge preparatory to swinging it to its open position is accomplished by means of levers at the top of the gallows frame which are moved by drawing up or letting out a chain passing around a shaft at the level of the tracks. The three rods which support the free end of the bridge are attached at the top of the gallows frame to the short arms of the levers, the ratio of the length of the lever arms being about 7 1/3 to 1. From the longer arms of the two outside levers, counterweights are hung, and from the longer arm of the center lever, a cable which terminates in a chain passing to a shaft at the track level. To this shaft are attached two ratchet wheels, one of which engages a pawl on a long lifting lever and the other a stationary pawl to prevent the chain from unwinding. The proportions of the levers and of the counterweights have been so designed that the end of the bridge is raised easily by two men at the lifting lever. A 4⅜-in. steel shaft is mounted in suitable pillow blocks on the top of the gallows frame to transmit the force exerted upon the central lever to those on the two ends.

At the Pelham Bay bridge additional levers were provided which engage a clamp splice on the cables just above the counterweights so that the strain can be taken off the cables when the bridge is closed by lifting the counterweights with these levers.

The short end of the top levers is shown in an accompanying illustration. It will be noted that the design is such as to allow the suspension rods to swing through a horizontal angle of 60 deg., and therefore remain in a vertical plane throughout the entire movement of the trusses, a very important feature in securing ease of operation. This necessitates a double pin connection which is accomplished by means of a clevis passing around a pin fitted into the end of the lever. The suspension rod ends in an eye and is fastened to the clevis with a 2 15/16-in. pin. Particular care must be taken in the design of the pillow blocks on top of the gallows frame because of the considerable weights coming upon them when the bridge is being swung. This precaution applies particularly to the pillow block in the center owing to the greater weight carried at that point. In order to secure smooth working in swinging the trusses it is advisable to set the upper lifting levers at an angle of about 15 deg. above the horizontal when the bridge is closed and resting upon the bearing plates on the rest end, so that when the bridge is raised off of these plates for swinging, the clevis may work in a horizontal plane. In order that the two levers on the ends of the gallows frame may not interfere with the back stay rods and stiff-legs it is necessary to bend them to one side, so that at the outer end where the cable is suspended, the lever is 6 in. to one side of its longitudinal axis at the pillow block. In this detail, the skew channel type of structure is easier to design than the right angle type, where the gallows frame is on a skew, for in the latter case a compound lever is necessary.



Pivot End of Truss.



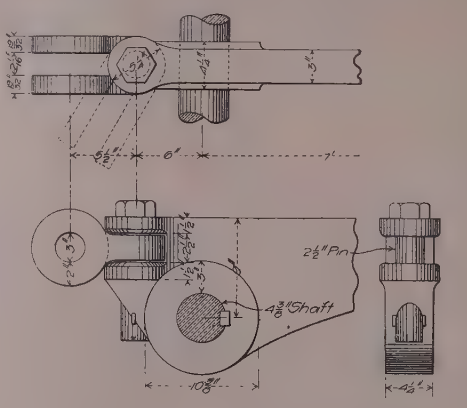
New Haven Standard Loading; Given in Axle Loads.

The suspension rods are 3 in. in diameter and are fitted with turnbuckles. Steel cables were first used, but because of the amount of stretch, did not give as satisfactory results as the rods.

The trusses, four in number, one under each line of rails, are of the Howe type, 9 ft. deep from the top of the upper chord to the bottom of the lower one, or 7 ft. 8 in. between chord centers. They are of different lengths, the shortest 65 ft. 5 5/16 in. between centers of bearings and the longest 76 ft. 1½ in. between bearings. The two trusses for each track are 5 ft. apart on centers, and the two inside trusses 8 ft. 6 in. They are hinged beneath the gallows frame, and when not resting on the bearing plates at the rest end are carried by a built-up swing beam to which are attached the three suspension rods running to the top of the gallows frame. This beam is 55½ ft. from the pivot center and the trusses are carried on it by means of suitable pivot bearings.

The truss chords are each made up of three 8 x 16-in. timbers of Oregon fir. Each of these timbers is a single stick, the two longest being 79 ft. The two shorter trusses are each divided into 10 panels, the longest into 12 panels and the remaining one into 11 panels, the panel length in each truss being practically constant. The diagonals are of yellow pine, the sections being varied according to the stresses.

The swing beam, 28 ft. 8 in. long, consists of two 20-in. 80-lb. I-beams spaced 17 in. apart with a 24 x 1-in. cover plate on top and six 24 x ½ in. x 2-ft. tie plates on the bottom. Between the two I-beams are riveted the three hangers for the pivot bolts for the suspension rods, and also the brackets through which are passed the pivot rods running through the centers of the cast-iron pivot bearing plates and the lower chords of the trusses.



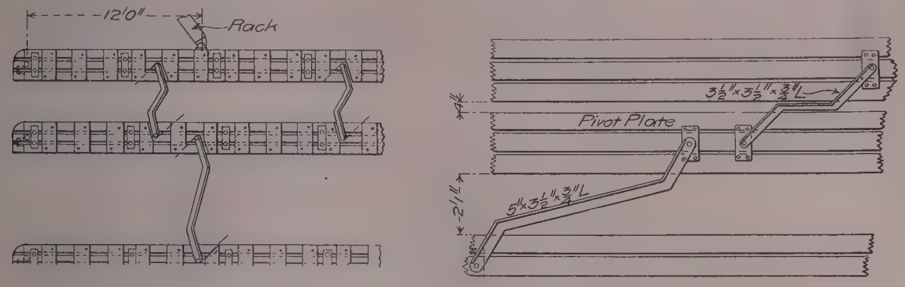
Short Arm of Lifting Lever.

The swaying of the trusses is prevented by means of bent brace bars, which are pivoted to both the bottom and top chords of adjacent trusses. For the trusses of each track these bars are 3½ x 3½ x ¾-in. angles and between the two center trusses 5 x 3½ x ¾-in. angles. The braces are bent so as to allow the trusses to lie close together when the bridge is swung open, the truss clearances then being but 4 in. for the two trusses of each track, and 25 in. for the two center trusses. Five braces are used between the two longest trusses, five between the two shortest, and four between the two tracks.

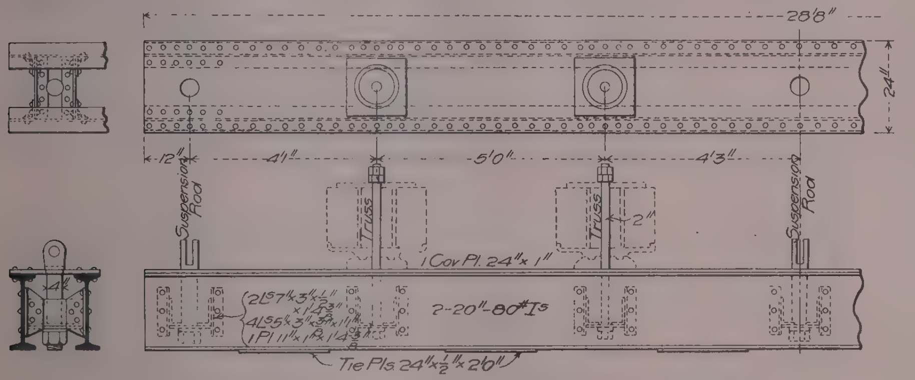
The pivoted ends of the trusses are carried on special cast-iron bearing plates while a hinge is placed immediately below the upper chord. Through this hinge and the center of the bearing plate is passed a 2¾-in. pivot bolt, 10 ft. 9 in. long.

One line of rails is laid on each truss, and is carried on 6 x 12 x 26-in. oak ties which are of the same length as the width of the truss. They are attached to the top chords by means of ¾ x 12-in. lag screws. On account of the angle taken by the brace bars when the bridge is swung open, the ties adjacent to them have their corners cut away. Guard rails are placed inside the track rails on the trusses and on the approach.

The draw span rails are connected with the approach tracks by stub connections, the shore rails being held firmly in position by flanged plates slotted to receive the projecting ends of the draw span rails. The latter, at the swinging end of the trusses, must be lifted out of the slots before the bridge is swung. At the pivot end the flange is omitted on one side permitting the rails to slide in and out as the trusses are rotated. The bridge is locked in service by steel bars about 18 in. long driven in on the outer side of the web of the rail, under the head, and by heavy angles riveted to the plate above described, and bearing against the other side of the web, filling the space completely, and lapping the stub ends equally. When slid into position by hand the bars are locked to the webs of the rails by a plug extending through the bar and the web and controlled by levers in the nearest signal tower, so that the bridge cannot be opened until the tower-man withdraws the plugs, having previously set the stop signals.



Position of Trusses when Bridge is Closed and Open, Showing Brace Bars.



Built-Up Swing Beam for Carrying Outer End of Trusses.

The "closing" of the openings or crowding of the trestle approaches is successfully taken care of by an extensive system of "bear-mouth" braces and tension rods. In hot weather the rails on the trusses require watching and occasional wedging to keep them from jamming against the stub shore ends and thus causing delay in operating the bridge.

The bridge is opened and closed by a rack and pinion device operated through gearing from a long handle, similar to the device used with the manual-swung center pivot bridge. The rack is attached to the longest truss 12 ft. from the pivot center. It is 15 ft. 9 in. long and, on the machinery platform, rests on three 8-in. rollers, which are 1 ft. 6 in., 1 ft. 9 in. and 3 ft. long. Three men are required to swing the bridge.

There are quite a number of details in connection with this type of structure which occasion considerable difficulty in design. The hinge strap for the trusses is apt to give trouble if the bolt hole does not allow ample play for the raising of the swing end, and if sufficient clearance is not left around it for the rotation of the trusses. The care which must be exercised in designing the bearings of the shaft running on top of the gallows frame has already been referred to. Wherever bolts are used cotters are placed outside of the nuts so as to insure against their loss and a possible displacement of the bolts. Both the back stay rods and the suspension rods require adjustment occasionally by means of the turnbuckles, but beyond this the bridge requires practically no attention to keep it in operation.

In constructing the bridge the trusses were framed on the ground back from the structure and then rolled out to the edge of the trestle where a lighter equipped with a derrick picked them up and placed them in the open position of the bridge.

On account of the network of piles which had to be driven there was danger of fouling the pile driver if the work was not done according to a pre-arranged plan. A diagram was, therefore, drawn up by the engineer in charge, showing every pile, and on this plan a sheet of paper cut to scale the exact size of the pile driver was manipulated in order to determine the best method of procedure. When this was fully worked out a driving program was drawn up and printed on a large sheet together with the plan of the piling. The latter was made additionally valuable by indicating graphically the cut-off of each pile by means of conventional symbols, each one of which indicated a different elevation. Copies of these sheets were supplied to the pile driving crews and in consequence no difficulty was experienced in getting in all the piles, and the completeness of the information and the order of the driving enabled the work to be carried on rapidly. All of the necessary dimensions including the spacing of the bents and of the piles in each bent were also embodied in this plan.

The design of the bridge except in details is similar to the former bridges in place at Westport and Cos Cob, Conn. The work was done under the direction of Mr. Edward Gagel, chief engineer of the New York, New Haven & Hartford R. R., and of Mr. W. H. Moore, engineer of bridges.

Additional Track Water Troughs have been installed during the past year by the Lake Shore & Michigan Southern Ry. between Buffalo and Chicago, for supplying water to locomotives while running. They are 2,000 ft. long, 2 ft. wide and 6 in. deep, and are placed about 50 miles apart. The total cost including the trough itself, the reballasting required, water tanks and heating devices, runs quite high, the ballasting especially being a costly item. In order to prevent the roadbed from heaving in freezing weather, the ground must be excavated 6 to 8 ft. and a filling of stone carried up to the roadbed level.

Rearrangement of Property Lines in the Suburbs of Frankfort.

The rearrangement of street and property lines in the suburbs of American cities has rarely been neecssary, because the cities have generally developed by a gridiron system of streets and there has been little need of making any change in it. In Germany, however, where the narrow, winding street lines have been established for long periods of time and property along them has been moderately developed, the problem presented by the change from suburban to urban conditions is quite complicated. The following explanation of it is given in the "Guide" to the public works of Frankfort-on-the-Main, prepared by the staff of City Engineer Koelle.

The rapid increase of the large towns in Germany during the last three decades—in Frankfort the population increased from 91,040 in 1871 to 288,989 in 1900—brought with it a number of problems requiring urgent solution by the authorities, and amongst these the question of providing housing accommodation was one of the most important. Numerous measures of the municipal authorities, such as the issue of a set of new building by-laws applicable to the various building zones into which the town had been divided, the preparation of a scheme for the extension of the town, the rendering of unhealthy areas more sanitary, the promotion of public and private building enterprise, the erection and letting of houses by the town, endeavored to solve the housing problem without, however, altogether preventing this question becoming a burning one, especially during times of rapid increase.

It is often the case that in addition to the demand for new houses exceeding the supply there is a lack of land available for building purposes, partly brought about by the land on the outskirts of the built-up portions belonging to a large landed proprietor who is not willing to sell, but chiefly by the land belonging to a large number of small owners, which renders its development for building purposes very difficult if not altogether impossible.

It is true the municipal authorities have the right to compulsorily acquire the land for new streets, but it often happens in such a case that, with a large number of small owners, the resulting plots, although abutting on the new street, are of such a size and shape, probably under an oblique angle to the street, that they are not suitable for building purposes. Even should some owners succeed in enlarging their property in the course of time by the purchase of adjoining plots and should develop it as a building estate, it nevertheless frequently happens that in the absence of a general adjustment of neighboring boundaries permanent injury results, either of an economic, sanitary, or aesthetic nature.

The building on unshapely sites or on sites at an oblique angle to the street entails an increase in the cost, owing to the irregular plan, results in difficulties as regards the division and shape of rooms, prevents the plentiful access of light and air, and offends further against the rule that, in the public interest, the architectural features of a street should be pleasing. It is, therefore, considered necessary in Germany for the public good that municipal authorities should have powers to readjust and rearrange—if necessary by compulsion—plots of land belonging to various owners, so as to lay out the land suitable for its proper development as a building estate.

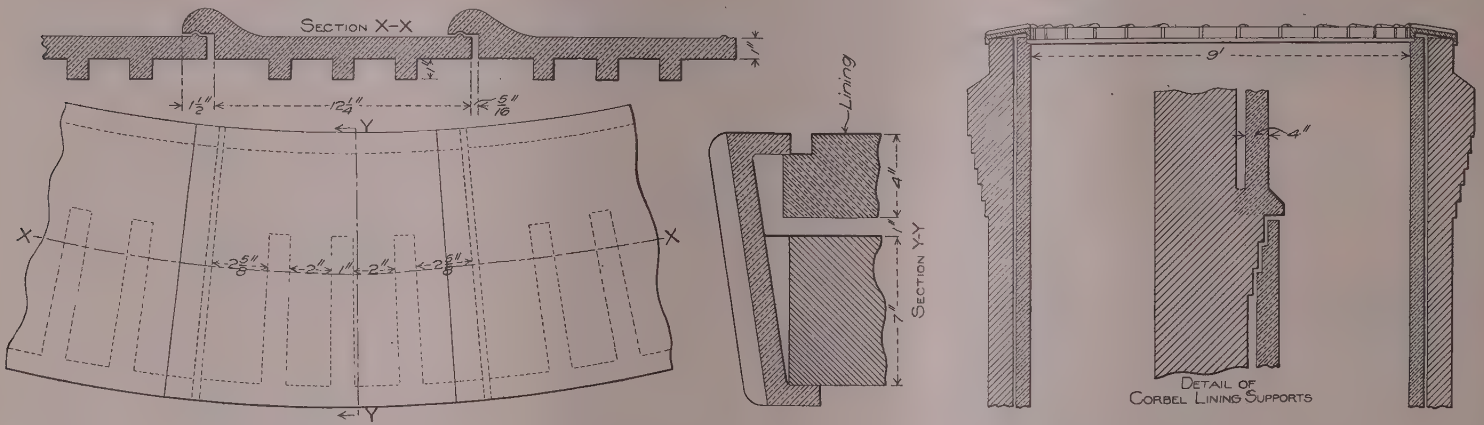
The various efforts made to remedy an untenable state of things in this respect have found a definite expression in the laws made by different states of the German Empire (Hessen, Hamburg, Baden) and by Switzerland. In Prussia the state of things, especially in Frankfort, where the land belongs to an extraordinarily large number of small owners, necessitated the attention of the Legislature. The Prussian Law of July 28, 1902, relating to the readjustment and rearrangement of plots of land belonging to various owners in Frankfort as well as the official report issued with the law of July 6, 1896, relating to streets in towns and villages in the Grand Duchy of Baden, may be named as the most thorough enactments for the regulation of this difficult matter.

The following are the chief points of the Frankfort law for regulating the readjustment and rearrangement of plots of land belonging to various owners (Umlegungsgesetz).

The readjustment of the boundaries of land belonging to various owners for the laying out of the land for building purposes is necessary in the public interest.

Nursery gardens and parks may be exempted.

The readjustment takes place at the request of the municipal authorities or if more than one-half of the owners, provided the latter own more than half the area in question, apply for it.



Details of the Terra Cotta Cap and Corbel Supports for the Lining of the Eastman Kodak Company's Chimney.

The land required for the streets and open spaces is first deducted from the total area and the remainder is then divided amongst the owners in the shape of suitable building sites according to the extent of their property.

Each owner to receive his new building plots as far as possible on the same site, on which his property was formerly situated.

The owners are to receive a money compensation for the land taken from them for streets and open spaces, if the latter exceeds 30 per cent. of the area of their property dealt with.

The value of the new building plots must be at least equal to the value of the original property, otherwise the owner must receive the difference in money.

In a like manner must the owner be compensated in money for the dispossession of houses and nursery gardens.

The readjustment of the boundaries and the rearrangement of the plots is done by a commission consisting of at least six members. Two of the commissioners are nominated by the governor of the district (Regierungspraesident), and amongst the other members there must be at least one well acquainted with building matters, one lawyer, one officially qualified surveyor and one other expert. The commission determines the time during which the streets and open spaces for the traffic and for building thereon are to be made, and when the readjustment is made at the request of the municipal authorities this period must, as a rule, not exceed four years.

These principles agree in nearly all points with those of the law of the Grand Duchy of Baden relating to streets in towns and villages, a prominent difference, however, being the treatment of the land required for streets and open spaces. Whereas in the Frankfort law this land is first deducted from the total area dealt with and up to 30 per cent. handed over free of charge to the authorities, the law of the Grand Duchy of Baden requires that this land shall first be bought by the authorities and that the owners shall afterwards reimburse the authorities when they commence building operations.

The efforts of the municipal authorities of Frankfort in the matter of opening out new building estates through the voluntary adjustment of the boundaries date back about a decade and have been successful—although in many cases only after very lengthy negotiations—to this extent that up to the end of 1903 an area of 257 acres has been opened out for building. It ought to be recorded here, that in all cases of readjustment of boundaries the land was soon sold for buildings, bringing in the owners a substantial profit.

The first case of a large voluntary adjustment of boundaries is the case of the so-called Kieshaide, a district comprising a total area of 35 acres and belonging to a very large number of owners, which may be described as a typical example.

The negotiations with the 54 interested parties were commenced in 1897, but led at first to no tangible result, as some owners, owing to want of experience, were over-cautious and refused to proceed. The negotiations were, however, persistently continued and in 1899 it became possible to lay out two plots. The hesitation of the owners became gradually less and in the following year two further plots were opened out. But the negotiations with the owners of the last five blocks were very prolonged, as, in spite of the general willingness to treat, the obstinate resistance of two owners had to be overcome, so that it was not till February, 1902, that the readjustment of the whole area was completed.

Although the principles acted upon in this voluntary readjustment correspond, as far as their results are concerned, with those laid down in the special law, they render, nevertheless, the whole procedure shorter and simpler.

In this case further—as in other similar ones—the whole area required for streets and open spaces was handed over to the authorities free of charge, whereas according to the special law the municipal authorities must compensate the owners, if this area exceeds 30 per cent. In passing it may be remarked here that no serious objections have been raised against a higher percentage and that the latter ranged in the Kieshaide district between 27.1 per cent. and 40 per cent. of the total area. This percentage was ascertained by calculating for each owner's plot the portion of land required for the new street up to its center line and the portion of land remaining and available for building purposes. This method was, however, abandoned in succeeding voluntary readjustments, and the practice is now—in agreement with the special law—to calculate the total area required for the streets and to divide the whole of the remaining area among the owners in the proportion of the extent of their original property.

With the readjustment of the boundaries the conditions for building on the new plots were settled and the municipal authorities undertook to make the streets—either temporarily or permanently—with water pipes and sewers, as soon as the necessary land had been handed over to them. For this work, including 3½ per cent. interest from the time of completion, the owners have to reimburse the authorities, when they commence building.

Nearly one-half of the Kieshaide district was built upon at the end of 1903, further buildings are proposed, fine new streets have been made, and the whole presents a pleasing picture of systematic modern town development.

The advantages of such a readjustment of boundaries and the rearrangement of plots of land belonging to various owners for the proper opening out and development of a building estate, are summarized as follows:

Buildings which are unsuitable in an economic and sanitary sense are prevented, and the future occupants do not suffer from ill-conditioned habitations.

The property of each owner is improved.

Ugly streets are avoided, all new streets are made with proper regard to existing thoroughfares, traffic difficulties which may last years are ab initio prevented, and a continuity in the development of a town brought about.

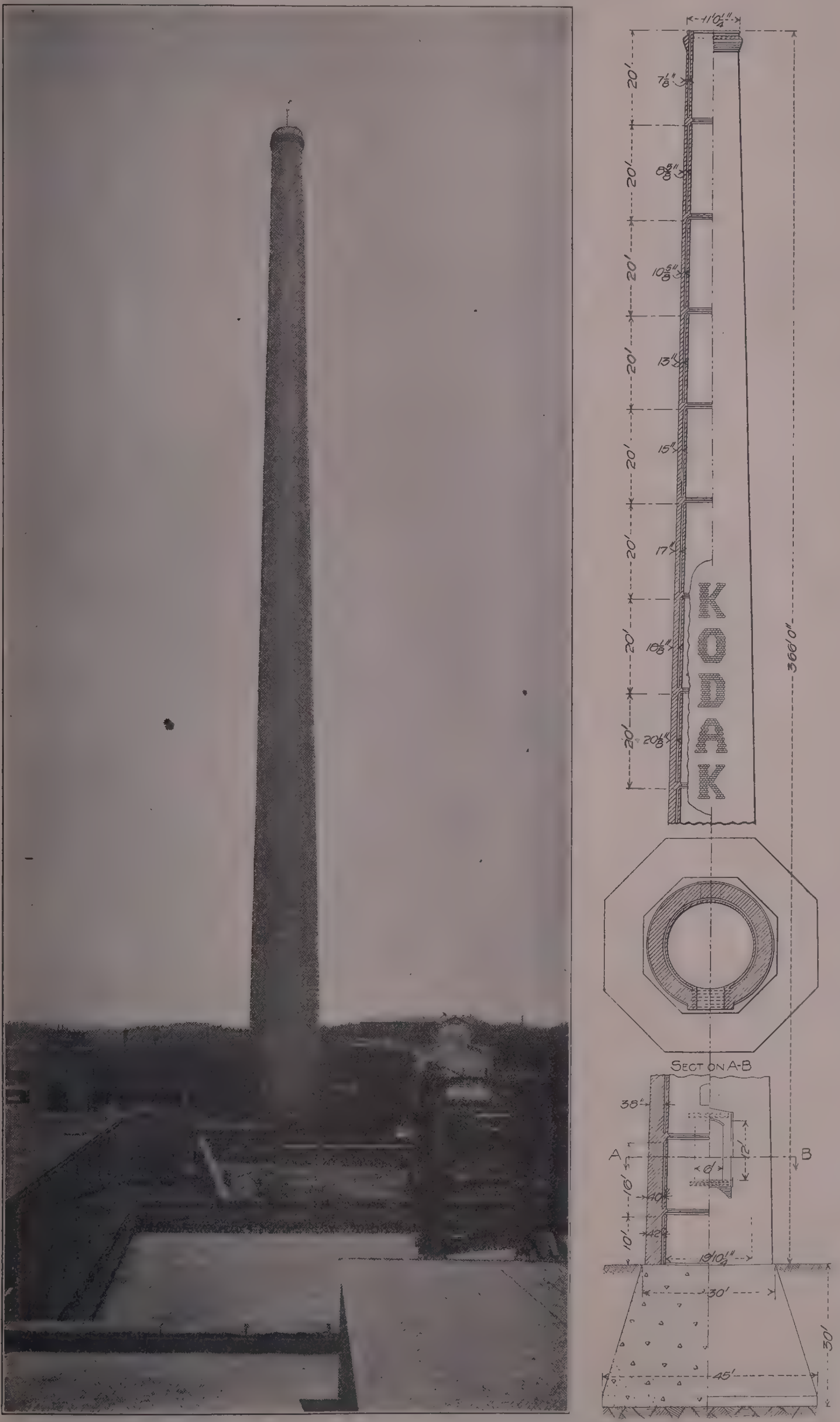
The market in available building land is enlarged and unwholesome speculation reduced.

The readjustment of the boundaries, with its tendency toward a wholesome reform in the private ownership of land, merits, therefore, a prominent place among the measures aiming at the solution of the housing problem, which is essentially a land question.

A Hydro-Electric Plant which utilizes the abandoned works of an old mining scheme is now under construction on the Feather River at Big Bend, Butte Co., Cal. A company was formed some years ago to mine a section of the bed of the river, and a tunnel 11,000 ft. long was driven for carrying the water through a point, thus leaving the stream bed dry for about seven miles. The enterprise for a number of reasons was not successful, according to "The Engineering and Mining Journal," and the tunnel was incapable of carrying all the water. The Great Western Power Co. will now enlarge the tunnel and lengthen it to 14,800 ft., at the same time lining it with concrete. The capacity will then be sufficient for the development of about 52,000 h. p. under the head of 400 ft. About 1,500 men are now employed on the construction and a trolley road about five miles long is being built for transporting men and materials. It is possible that mining may be resumed in the river bed when the entire discharge is passed through the tunnel.

A Tall Brick Chimney with Acid-Proof Lining.

A 366-ft. brick chimney, the tallest chimney that has yet been built in America, has recently been completed at the Kodak Park Works of the Eastman Kodak Co., Rochester, N. Y. The chimney is of special construction, designed and built by the Alphons Custodis Chimney Construction Co., New York City, for carying off strong acid fumes. The great height was necessary to prevent the nitric acid fumes from the acid plant of the manufacturing department becoming a serious nuisance in the neighborhood of the works. The acid plant of the Eastman Company is one of the largest of its kind in this country, but is so thoroughly ventilated that scarcely an odor of acid is discernible at the plant, so thoroughly is every aperture in the apparatus closed. It is necessary for workmen to stand over great open vessels of acids in which cotton is being treated for making the base of the transparent film, to stir the mixture, and large fans rapidly withdraw the air above into big receptacles and carry the acid fumes into the flue leading to the chimney. These acid fumes have a temperature of 200° Fahr. and condensate to a great extent, destroying concrete or ordinary brickwork in a short time, and it was therefore necessary to make the flue connections as well as the chimney entirely acid proof. The chimney is lined throughout from top to bottom with a special lining of radial brick which has both heat and acid resisting properties. It was at first decided, after a thorough investigation, to build a chimney 350 ft. high, but as the tallest chimney in America was then 365 ft. high, that at the works of the Orford Copper Co., at Constable Hook, N. J., the Eastman Kodak people thought to exceed this height and make the chimney 366 ft. high, therefore getting the tallest chimney in the world.



The 366-Foot Chimney of the Eastman Kodak Co., Rochester, N. Y.

It was first intended by the Eastman Kodak Co. to have only the acid fumes enter into this chimney, but as a new power plant was being erected and a chimney needed for 2,000 h. p. of boilers, it was decided to utilize the chimney for the gases from the boilers, thereby reducing the condensation of the acid fumes in the chimney. The chimney was made of ample capacity in area to take care of this additional work, and the height was amply sufficient to create the necessary draft.

As rock strata underlies the site at depths of from 20 to 30 ft. the foundation of the chimney was carried down about 30 ft. below the surface of the ground to solid rock. The foundation was built of concrete consisting of one part of Portland cement, three parts of sand and five parts of broken stone, and is of octagonal form, 30 ft. in width at the top and about 45 ft. at the bottom. The concrete is protected at the top by an acid proof pavement from the influence of the acid fumes in case of condensation.

The chimney proper is a brick cone, having a uniform taper of 4.6 in 100 ft. for both sides, the outside diameter at the foot of the chimney being 27 ft. 10¾ in., and at the top of the chimney 11ft. 0-¼ in. The construction is of the special Custodis perforated chimney blocks of radial or segmental form, which are made in five different lengths, 4 in., 5½ in., 7⅛ in., 8⅝ in. and 10⅝ in., and in this manner a very strong bond is secured in the chimney walls. Blocks of varying radii are used for the various diameters of the chimney structure and are 4½ in. thick and 6½ in. wide on their external faces. These blocks are formed with perforations, which perforations not only facilitate the proper burning of the brick in manufacture, but also permit a much stronger bond with the mortar than with sold bricks. Tests have shown that the adhesive power of mortar between perforated bricks is 61½ lbs. per square inch, as against 21¾ lbs. per square inch with solid brick blocks, or nearly three times as much. The blocks are laid up in cement mortar with sufficient quantity of lime added to make the structure elastic to withstand the vibration caused by strong wind storms.

The walls of the chimney vary in thickness from 42 in. at the foot of the column to 7⅛ in. at the top, exclusive of the acid proof lining, which is of uniform 4 in. thickness throughout. The chimney is of sufficient width and taper to eliminate any tension in the brickwork at any point under a maximum wind storm of 100 miles per hour, which is equal to a pressure of 50 lbs. per square foot of flat surface, or 25 lbs. on the projected area of a cylindrical surface. A maximum compression due to the weight and wind pressure is computed at 21 tons per square foot, on the leeward side. The wall thicknesses are changed every 20 ft., the difference being 2 in., thus dividing the entire structure into 19 sections, the lower two of which are 16 and 10 ft. high.

The acid proof lining consists of a 4 in. radial block which was especially made to resist the influence of the strong acids. Tests showed that the blocks after being submerged in muriatic, sulphuric and nitric acids in diluted and concentrated form for several days had not been damaged to the least extent. The lining is supported on corbels extending from the main walls of the chimney at every offset, thus increasing the stability of the chimney greatly by having the weight of this lining rest on the main walls of the chimney. The lining is separated from the main wall by an air space of 2 in., and the top of each section of lining is protected from the influence of the acid which might possibly through condensation flow down on the inside of the chimney by a special form brick. Advantages of considerable importance are claimed for this type of sectional lining, which is controlled by the Custodis Company, as to cheapness and ease of repair—a self-supporting lining requires a much thicker wall at the bottom to support the wall of the upper portions. The lining is laid up in an acid proof mortar which is capable of resisting successfully the influence of the strongest acids in diluted or concentrated form. This mortar has a great binding power and can withstand a temperature of 2000° Fahr. The mortar consists mainly of silicate of soda and asbestos wool and is tempered to the consistency of fire clay mortar, thus enabling the blocks to be laid with mortar joints of a minimum thickness. The lining is constructed so that it is entirely acid proof, but if at any time any part should wear out or become damaged, it is only necessary with this sectional construction to repair one section where the damage is located without disturbance to the rest of the lining as would be the case with a self-supporting lining.

The top of the chimney is protected by a terra cotta cap of acid proof clay, for the purpose of resisting the corrosive action of acid condensation. The cap is formed of 30 terra cotta tiles of radial form with overlapping joints on the radial edges and downward projecting lips on both inner and outer edges to cover both shell and lining. The tiles have inclined radial ribs so placed near the outer edges as to rest on the outer shell blocks and give the cap an inclined position sloping outward. The tiles rest entirely on the top of the outer shell blocks, to which they are cemented, and merely overlap the top of the lining, which is thus permitted free expansion and contraction with ample protection of the lining from the weather. The overlapping radial joints are made tight and with acid-proof mortar.

Protection from lightning is afforded the stack by a four-point lightning arrester consisting of a ½ in. stranded copper cable, fastened to the chimney by means of copper clamps and connected in the ground at the base of the chimney to a copper plate. The four points at the top are connected with a copper ring that encircles the head of the chimney and connects to the main conductor. The points themselves are of retort graphite, fitted in brass sleeves and supported on copper mountings, copper and brass being used throughout in preference to galvanized iron in order to resist the corrosive effect of the acid fumes which might descend on the outside of the chimney in rainy weather. The chimney has an outside ladder and the name Kodak is worked in the outer shell, with dark colored blocks, which color is burned into the clay to make the color weather proof.

The Alphons Custodis Chimney Construction Co. has built numerous other chimneys of less height for chemical works, and this special construction has successfuly withstood the action of all kinds of acids. They have at present under construction at Great Falls, Mont., an acid proof chimney which will be when completed the tallest and largest chimney in the world, as it is to be 506 ft. high and to have an internal diameter at the top of 50 ft. The duty of this immense chimney will be to carry off 4,000,000 cu. ft. of sulphur gases per minute. It will take about a year and a half to complete this structure.

Gas Booster Units, each consisting of a 70-h.-p. De Laval steam turbine and a Sturtevant blower, have been installed at the gas works at Croyden, England, to raise the pressure in the mains when necessary.

A Plea for the Broader Education of the Chemical Engineer.

An address by Clifford Richardson before Section C, American Association for the Advancement of Science.

It has become my duty, under a provision of the constitution of the American Association for the Advancement of Science, to mark my retirement from the office of Vice-President and Chairman of Section C, by an address. Sir Boverton Redwood remarked on a recent occasion that such addresses offer an opportunity for the dissemination, from time to time, of highly specialized information. I might follow this custom and talk to you about one of the chemical industries in which I have specialized, but these subjects are of such limited interest that I shall avoid them and turn to one which appeals to me as being of the greatest importance at the present time, although, at first thought, it may seem to have received sufficient consideration of late, in view of the address of my predecessor in office, and many others, on the same and allied subjects. I believe, however, that no apology is necessary for asking your attention to the subject of the education of the chemical engineer, and this will include what he should be in the light of what he will be called upon to do, what characteristics he should possess, how he should be directed and encouraged, what training he should submit himself to in order to meet the demands which will be made upon him, and, finally, how his profession may be raised thereby to the level of the other learned professions, such as law, medicine and civil engineering, as exemplified by their most successful practitioners and representatives, since it is not too much to hope that it may, in the near future, be elevated to a place of due honor and prominence and given proper recognition in our national life, and that, eventually, the chemical engineer may fill many of the executive and administrative offices of our largest and most important industries.

That our industrial progress within the last half century has been phenomenal is too evident to require mention. Much of it has been based, however, on a very wasteful use of our natural resources, and, with their approaching exhaustion, reforms must be instituted and economies practiced. There is a marked demand for an improvement in the quality of the output of some of our industries. The field for invention of new processes and new products is large. That the chemical engineer will play a large part in the development and regulation of the industries of the country along these lines cannot be denied. It is already evident in what he has done in connection with the use of the electric current available at Niagara Falls and elsewhere. He has become, and will remain, the main stay in certain particulars of the regulation and development of our many industries.

President Stone, of Purdue University, has said:

"True industrial progress consists in utilizing with ever-increasing economy and accuracy, natural forces and materials by more scientific methods of operation and management, in securing better conditions of life for industrial workers, in furnishing products of better quality at lower cost, and narrowing the gap between the employer and the employee. There comes a time inevitably when the mine is empty, the forest destroyed, the virgin soil exhausted. Then will arise the real question of industrial ability which can only be met by education and training."

As the chemical engineer will have a large part in solving this problem, and as the demand for his services must increase to a great extent, it becomes an important question as to how he shall be selected, educated and trained to fill the rôle which he will have to play. It is this question which I wish to discuss to-day in the light of the opinions which have been expressed by others, and in that of my own experience, the latter being that the graduate of our technical and scientific schools who proposes to adopt the career of chemical engineer is the product of a too narrow training, being at the best an expert chemist, and in no sense fitted to deal with affairs or impress himself upon others. My plea will be for a broader education for the young man who proposes to become a chemical engineer, and for avoiding the making of the intense specialist with his narrow point of view and lack of culture. My remarks will be addressed as well to the young man who is contemplating entering upon such a career, or is already in preparation for it, as to those who will be responsible for his training, or, as industrialists, look forward to the advantages to be derived from having available broad-minded, liberally educated and cultivated men who are, at the same time, chemists and men of affairs, and, as such, fitted to take part in the development of our industries.

We must formulate our idea of what constitutes a chemical engineer. In my opinion, a chemical engineer is, primarily, a chemist, but essentially a man of affairs and executive ability who is engaged in the application of the principles of chemistry in the arts and industries, with special reference to the commercial development of the industries and establishment of new ones, to perfecting the arts, and by his advice and co-operation, assisting other engineers in the practice of their professions.

There are, of course, many types of chemical engineer; the inventive type, in some ways the highest, the type which adapts and makes practicable the discoveries of the inventor; the administrative and economic type, which is that of a large number of the profession; the constructive type, dealing principally with the design and construction of apparatus and plants, and approaching more nearly the civil and mechanical engineer; and, finally, the advisory type, which is engaged almost entirely in a consulting and inspecting capacity, and which more nearly resembles the counsellor at law and is closely allied with him in litigation involving facts or opinions which must be interpreted in the light of chemical principles or experience. The type into which any individual may develop will depend upon his temperament and aptitude and upon the opportunities which he may have opened to him.

The mere technologist or industrial chemist is often confused with the chemical engineer, but should be sharply distinguished from him. The former is merely acquainted with the details of the various arts and industries, as they are carried on at present, and he sees that they are properly conducted according to rule and custom. He does not originate, nor does he study them from the point of view of the chemical investigator. He is more nearly an empiric. He is unable to meet the demands which are made upon the chemical engineer, or to take a leading part in the affairs of the world.

The chemical engineer must not be content to remain a mere technical man. He must be practical. As President Humphrey has remarked of the civil engineer: "His work must be based upon correct and complete theory, but it must be, first and last, practical," and Prof. John Perry calls attention to the fact that: "He must have all the knowledge of the scientific man, and ever so much more. He uses the methods of the scientific man and adds to them methods of his own. * * They come to him through a very wide experience of engineering processes, of acquaintance with things and men."

We should have in the chemical engineer, at once, the thorough chemist, the man of imagination, the leader of men who inspires confidence in those about him. He should be an executive of the first order, who, having an eye for the selection of others of a capacity for special duties, is able to direct them so as to obtain the greatest return from their services. He should not waste a moment's time in doing anything which another can do equally well, and should reserve all his energies for the higher problems which may be met. He should have tact in dealing with others, and, in particular, should be able to express himself by word of mouth and in writing in a forceful manner; that is to say, he sould have command of the English language and some literary capacity. He should also have a knowledge of German and French, so that the scientific literature of these countries may be available to him and enable him to keep in touch with the specialists who are at work there in his own and allied professions. He must be at all times a student and a wide reader. He should not neglect research and should inspire his subordinates with the necessity of it for the prevention of that tendency to fall into a rut which is so common. He should be a man of personality to enable him to make a favorable impression upon those with whom he is brought in contact. He should avoid all antagonisms and should only permit himself to indulge in destructive criticism on rare occasions. Above all, he should possess initiative, imagination and perspective. He should be a person of original ideas and not a mere follower of those of others. He should not be afraid of the improbable and the unlikely, and, in this respect, may well take to heart the advice of Sir William Ramsay.

For the making of the successful chemical engineer, as for other professions, the best material only is suitable, if the result is to be more than mediocre. Unfortunately, the human race is not bred to points, either physically, mentally, or for special aptitudes, in the same way that is practiced with the race horse, with high-grade cattle or dogs, to develop their most desirable characteristics; the importance of national eugenics has only recently been brought to our attention by Galton and Pearson. We have recourse, therefore, only to what chance may produce. Nevertheless, chance has done much for us. Prof. H. H. Armstrong calls attention to the fact that:

"Americans may be said to be a distinct if not an improved breed. Certain proclivities have been, undoubtedly, unconsciously selected out and there has been much cross-breeding; hence a race has developed differing in important respects in its type of thought if in no other way, from those represented in Europe. Moreover, success has given them belief in themselves, and leads them to trust themselves."

We should make our choice of those youths who have had the best of home discipline and restraint. Sir John E. Gorst calls attention to the fact that: "The chief causes which produce formation of character are met with in the homes of the people."

The individual who has been subjected to the most favorable environment in his early years, and in the secondary schools will be the most satisfactory, if he possesses the proper aptitude to be a chemical engineer.

Aptitude, or what is sometimes denominated a natural gift, is inborn and must be sought out. It cannot be developed, but may be encouraged and directed. Prof. A. Lawrence Lowell, of Harvard, has wisely said that the problem of the schools is to discover and stimulate the right kind of men more than to directly instruct them. There is too great a tendency to attempt to make chemical engineers out of all who have a fancy for dabbling in a laboratory. For this reason, it seems to me, a great responsibility rests upon our schools in guiding the youth into proper channels and restraining him from fields where he can only meet with disappointment.

Taking what chance may offer as regards breeding, and chance at times offers very good material if we exercise selection, we must endeavor to impart direction from the earliest years of the individual's training. "It is for wise direction that the coming generations cry; and it is our business to see that they get it," as the Man of Science remarks in "A Modern Symposium." In our secondary schools there is too little consideration of the individual or of his direction. There is too much routine, too much system and uniformity. The bright and the dull boys are advanced through the various grades at the same rate. What we need is, as stated by President Eliot, the promotion or advancement of each pupil by subject and not by mere time. By the present system much time is lost to the bright boy. Individuality, and not uniformity, should be the rule in all branches of education, and particularly in the case of those who propose to become professional men. Mr. Böttger appreciates the situation in our American high schools when he says: "In America one finds the object of the high school instruction to be to enlarge the capacity of the average man, while in Germany the main object is well known to be the complete development of the best students."

While this object is a praiseworthy one, as applied to the average man in America, it is not satisfactory in the case of those who propose to follow a professional career. President Remsen, however, in reviewing Böttger's book, thinks that, while it may be true of our colleges and technical schools, it is wrong as regards the graduate work of our universities, and this is probably true of our graduate schools of the higher class, but plainly not so in those which turn out some of our weaker doctors of philosophy.

Hugo Münsterberg points out in a way well worthy of consideration some of the faults of our secondary educational system. He says: "I do not want to be misunderstood as seeing no fault in the American system of instruction. There are not a few wrong tones which hurt the ear of the newcomer, discords to which he will never become insensible. But these fundamental errors belong to the school rather than to the college. It is enough to point out the most devastating one: the lack of mental discipline at the very beginning of the intellectual growth. The school methods appeal to the natural desires and do not train in overcoming desires; they plead instead of commanding; they teach one to follow the path of the least resistance instead of teaching to obey. The result is a flabby inefficiency, a loose vagueness and inaccuracy, an acquaintance with a hundred things and a mastery of none. Public life has to suffer for it, a community which did not get a rigid mental discipline through home and school influence must always remain the plaything of the lower instincts.

"How much more the American college might have been able to produce if it could have received into its freshmen class young disciplined minds, trained in accurate and careful learning and in the restraint of primitive impulses! The college would not have been burdened by wasting much of its costly time in repeating the elements of learning and patching up the slang-disfigured English language."

Prof. C. A. Waldo, in his vice-presidential address before Section D of the A. A. A. S. at St. Louis in 1903, on "The Relation of Mathematics to Engineering," said, dealing with the question of our preparatory schools: "This is the indictment of the schools, that they use, largely to the exclusion of the thought element, a mass of formal and conventional educational material and thus paralyze thought and make abortive any natural mental growth."

Prof. J. J. Stevenson remarks (Pop. Sci. Monthly, January, 1904): "The old adage says, 'He who would command must first learn to obey.' That American lads are sorely in need of such training is only too evident. . . . Such training means training to think, to reason. Lads often fail to receive this training in secondary schools, as any instructor who has had to deal with freshmen can testify. Secondary schools to-day are little better than cramming houses to fit pupils to answer odds and ends of questions in papers for entrance examinations. Loose training and restlessness under restraint characterize the American student in the lower classes at college; lack of home training may be in part responsible for the latter characteristic, inferior teaching in secondary schools for the former."

There is much of truth in the preceding assertions. Our secondary and high schools are unsatisfactory. They offer to the colleges a mass of more or less unformed material which must be worked over again at great loss of time and energy. It is evident, therefore, that one of the first steps in the improvement of the education of the chemical, or, in fact, of any engineer, lies in a modification of his early training.

If we cannot expect as much as might be desired from the secondary schools, we may at least study the material that is offered, selecting and directing that which is most suitable for encouragement, but we must not force the crude product into the professional schools. That, it seems to me, is the great crime of to-day, especially in the case of those who propose to become engineers of any type.

What provision can be made to avoid these difficulties? I believe this lies in postponing professional training, except in so far as elementary science may form a part of any ordinary liberal education, until a proper foundation can be laid for it. We do not find at universities of the highest standing that students are received into the schools of law or medicine until they have prepared themselves for the study of these professions by a liberal education involving the taking of a bachelor's degree, which is accompanied by the attainment of the necessary degree of maturity. Is chemistry as a profession one which does not need the same foundation? In my opinion, this is not the case. A sound foundation is quite as much needed as in law or medicine.

The subject has been discussed, pro and con, at great length in numerous recent addresses. Prof. George F. Swain, in opening a discussion on "Engineering Education" before the American Society of Civil Engineers in 1906, said:

"Most people will admit to-day that civil engineering, like other branches of engineering, belongs to the learned professions and should require a preliminary training corresponding to that necessary for the lawyer or physician. The trouble with the young man between the ages of sixteen and twenty-two, who is given the opportunity of a higher education, is that he fails to realize his opportunity and does not take advantage of it, and, as a result, many of the graduates of technical schools and colleges have neither accurate knowledge of any one subject, nor the ability to think clearly and logically, nor the power of taking up a new subject and mastering its fundamental principles without assistance. . . . In laying out an engineering course the aim should be, first of all, to develop broad-minded men who can observe correctly, reason logically, express themselves in language and on paper, men with imagination and with character, and with good physical development."

He adds:

"Studies which involve discipline of the mind and observation should be preferred to those which merely give information. Subject to the above restrictions, what is taught is not as important as how it is taught. The choice of a profession should be made as early as practicable and a continuous course should be arranged with that profession in view from the beginning of the higher education."

Prof. Hugo Münsterberg, in a recent address at Lafayette College, already referred to, in which he sings a song of praise for the American college and advocates the establishment of one in Germany at Hamburg, says:

"The idea was that in Hamburg, just as in Harvard, the youth ought to get in common in years of academic freedom, the inspiration of cultural work in history and economics, in literature and philosophy, in art and natural science, before their ways are divided to go either to the professional schools of the typical German university or to the practical enterprises which commerce or industry or agriculture or politics may offer.

"That which is needed for the Germany of today, and still more for the Germany of tomorrow, is an academic institute of a new type—a university where the full freedom of academic life can be joined to studies of a purely cultural character, where young men may enter two years before they have reached the present goal of the professional university, and where a three or four years' course would prepare them for the duties of life without any thought of their later occupation."

He adds that, in America: "Public opinion was thus imbued with the correct idea that these professional studies did not in themselves guarantee a high level of culture. The real culture, on the other hand, the making of a gentleman, was left to the college. . . . The highest professional schools to-day demand the bachelor degree at their threshold."

If Prof. Münsterberg demands something of the sort for Germany, why should it not be put to greater use in the education of our chemical engineers in this country, where it can be had for the asking?

The board of visitors to the Military Academy at West Point for the present year appreciated the necessity of overhauling the curriculum at that institution, with a view to bringing about a broader culture, the course now evidently being too intensive. The board states: "An officer of the army should be an all-around educated gentleman. As it is now, his entire training, both preparatory at the academy and post-graduate, is almost purely technical." And within a few weeks President Schurman, of Cornell, has emphasized the importance of such considerations in his annual report for 1906-1907.

In an address well worthy of careful consideration, before the graduating class of the Rose Polytechnic Institute in 1903, Dr. C. B. Mendenhall, of the University of Wisconsin, discussed the subject of whether the technical education there given compared favorably with the so-called liberal education of the regular college or university. He concludes:

"It is apparent, then, that technical education as at present understood, is strong in the matter of the discipline of the mind and will; it will help a student to think clearly; it will give him self-confidence and self-control, and teach him the virtue of the necessity for work. It is equally apparent that the system is weak on the side of broad general knowledge and cultivation, and there is no doubt that this is a serious defect," and, after discussing various remedies for the situation, he adds: "In ways like these will it become more and more true, let us hope, that the engineering graduate has had the essential features of a liberal education in addition to his professional training." He asks the question:

"But do we fully grasp the fact that we are called upon to be broad men as well as specialists, and that there is a sort of success to be attained quite distinct from our professions?"

The president of Case School, in his inaugural address in 1904, said: "It (a technical course) does not teach him all that an educated man ought to know. It would be much better if our technical graduates were broadly educated men as well as trained engineers, if they had received a college training before entering on a technical course. . . . I believe the student should be trained to know, to search, to think, before he enters the technical school. During his whole life he would have a broader outlook, a deeper sympathy with men and events, a greater influence upon the community. I am sure he would be a better engineer."

President James, in his inaugural address on assuming the office of president of the University of Illinois, in 1905, said: "The university is the institution which furnishes a special professional, technical training for some particular calling. This special, technical, professional training must, however, be scientific in character and must be based upon adequate preliminary preparation of a liberal sort. By this requirement of a liberal preparatory training, the university is differentiated from the technical school or trade school of secondary grade."

In the light of the preceding statements it would seem that my plea for a broader education of the man who is to adopt a professional career has been supported very generally by those who have given the subject consideration. The requirements of the Harvard schools of medicine and law are recognized as applicable to other professional schools, and in this respect I am putting forward nothing novel. I believe, however, that but little has ever been said in regard to the necessity of a similar requirement in the schools where our chemical engineers are trained, although an equal necessity, in my opinion, exists. I am ready to grant that the individual who proposes to follow the career of an investigator in pure science may, perhaps, succeed by specializing from his earliest years, but it cannot be granted in the case of the engineer who must train himself as well to deal with men and affairs as with his strictly professional subjects.

The question, of course, always arises as to what the education shall be of those who are to occupy places of minor rank, and form the rank and file of industrial chemists, but who will never attain eminence as chemical engineers. Here a good education is demanded along technical lines, alone, and, in the more narrow field, little also is called for. Our technical schools can accomplish this work, but there is always danger that the graduate may be led to think that his degree, without any regard to his natural abilities, will lead him to the higher places in the profession, and, when he finds that he is not the great success that he has pictured to himself, he blames the system of education, and not entirely without cause. There are too many graduates of the technical schools, especially of the Middle West, who are spoiled by being educated beyond their capacities. They would be better off with a good high school education and with a trade. This, however, is a different problem from that which we are considering. What we must take up is, How can the student of sufficient capacity obtain the training and education for which I have pleaded? It will, of course, involve the expenditure of more time and money than if the mere technical training is sought. If time and money are insuperable objections, the more satisfactory course must be abandoned, and reliance placed upon the possibility of making up the deficiencies in the school of application in after life. It is my belief, however, that great efforts should be made to follow the course which I have laid down. On its completion the man will find himself a more matured and better informed person, he will have greater confidence in himself, he will make a better impression on those with whom he comes in contact, and will command a greater remuneration. He will find that he is well repaid for the effort which has been made. Of course, in the case of the individual who is not hampered for means or time, there can be no question, for the same reasons, as to what to do.

It has not been the usual course for the chemist as yet. It approaches more nearly to that of the college graduate who, with the A. B. degree, spends three or more years in obtaining a Ph. D., and, as far as a knowledge of chemistry is concerned, such a course would be satisfactory. As Prof. L. M. Dennis has remarked: "There should be no distinction between the training of the technical chemist and one who is to devote himself to pure science and investigation."

The chemist who is to become a chemical engineer, however, must also be equipped in other ways which cannot be done in the mere attainment of a doctorate. He must acquire his professional attainments in a different school and atmosphere. He must perfect himself in allied subjects and be competent to co-operate with other engineers.

My own idea is that the plan offered by Harvard will furnish the most desirable training for the chemical engineer, whether practiced at that university or elsewhere. At Harvard, on the point system, a liberal education and the bachelor's degree can readily be attained in three years by one of slightly more than average ambition. During these three years he will have been subject to an environment which will mature and broaden him, if there are any broad qualities to be brought out. He will find himself and his capacity, and how to direct himself. He can, in addition to the liberal courses which he may take, select such others as will enable him to satisfactorily enter the Graduate School of Applied Science and to there pursue his technical studies. He is in a position to take up the professional work of the school, with every probability of approaching it as a mature and well-balanced man. Two years in this school is rewarded with the degree of Master of Science in Chemistry, and the graduate is then ready for more advanced studies or for entrance into the final and great school of application.

At the present time the number of students in the Graduate School of Applied Science at Harvard is sixty-three, of which, I regret to say, only one is a student of chemistry. This is not large, as compared with many of our scientific and technical schools, but the quality of the men enrolled, and the number of undergraduates in Harvard College who look forward to entering this school later, and are planning their work to that end, is so large that the Corporation of Harvard is entirely satisfied with the experiment that it has made. It is, in fact, so well satisfied that within a few weeks it has definitely committed the university to the policy of placing the technical work in the university on a graduate basis, and it has closed the Lawrence Scientific School to the further admission of new students.

It is evident, therefore, that Harvard University has made a very great step in advance along the lines which I have suggested for the preparation of the individual for professional studies and fitting him to become a chemical engineer. It seems to me that it will acquire the same reputation for its move in this direction as it has in its law and medical schools.

At Columbia a simlar course can be pursued, taking the B. A. in the college or the B. S. in the scientific school after four years' study, and then proceeding in two years to the degree of chemical engineer.

Johns Hopkins has a Graduate School of Applied Science, largely devoted to research, while in 1903 the Massachusetts Institute of Technology issued a prospectus for a Graduate School of Engineering, leading to the degree of Doctor of Engineering, which has not as yet materialized to any great extent, but which we may hope to see encouraged under the direction of the present acting president of the institute, our colleague, Dr. A. A. Noyes.

There are, no doubt, equally satisfactory opportunities in other schools for such a training as I have demanded, if the desire for it is expressed, and I would by no means suggest that continuous study in any one locality is necessary or even desirable.

The instruction in some of our schools is intensive; in others broad. In one the student meets an environment which is purely local, in so far as all or the majority of the instructors are graduates of the school in which they teach. In another they have been assembled from a wider field, have brought to the school a broader conception of the science, and a more liberal point of view. The latter is surely the more desirable. It is quite possible, therefore, that it may be as well to move from place to place for the change of atmosphere which may be obtained.

The main thing to be accomplished is the making of the liberal minded man of broad intelligence who shall possess those qualities which I have cited as being necessary in the chemical engineer and which, in my opinion, are not found in the graduates of our technical schools as they are thrown on the world.

If time and my confidence in your patience permitted, I might go at length into some other defects in our system of educating the chemical engineer, more especially as to the evils of examinations and of making undue exertions to obtain degrees. But these subjects must be reserved for another time and place. The views of many prominent persons in regard to them are well known to you, and I may add that I am in sympathy with the idea that they are both evils which need very careful consideration.

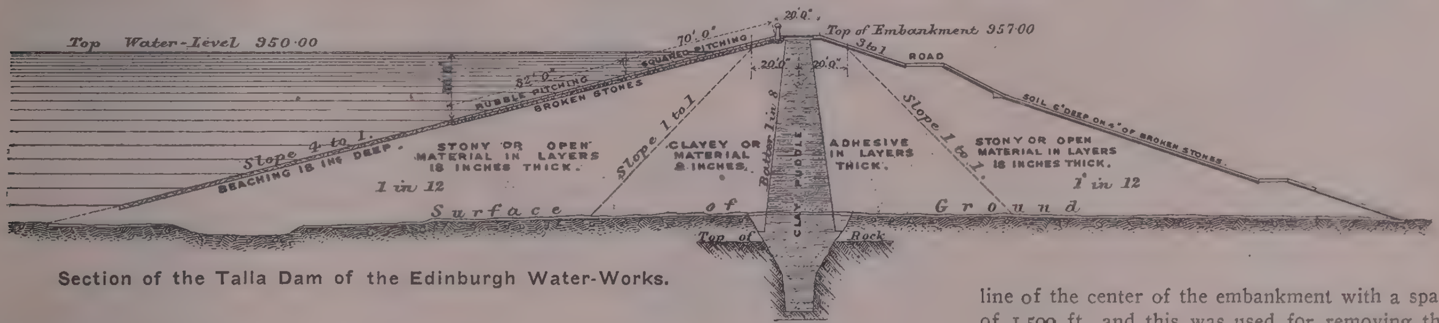
It is to be hoped that the suggestions which have been made, although in no way novel, may, by reiteration, arouse some attention in so far as they may point out a way of making the chemical engineer of the future a larger, broader and more influential man than he is to-day, and one who will occupy a position of as great importance as leaders of the other great professions.

SHORTLEAF PINE, extensively used in buildings, has been tested for the U. S. Forest Service at Purdue University, thoroughly green beams 16 ft. long from 8 x 12 to 8 x 16 in. being used. The modulus of rupture ranged from 4,050 to 7,730 lb. per square inch, averaging 5,500 lb.; the modulus of elasticity ranged from 1,041,000 to 2,069,000 lb., averaging 1,470,000 lb.; and the horizontal shearing stress at maximum load ranged from 204 to 459 lb. per square inch, averaging 313 lb. The large number of beams failing in horizontal shear emphasizes the importance of considering this factor in design. Of seventeen select beams, eight failed in horizontal shear, and of 31 merchantable beams three so failed.

The Talla Water Supply, Edinburgh, Scotland.

An additional supply of water for Edinburgh, Scotland, and its environs, of about 14,500,000 imp. gal. per day, has recently been made available by the completion of the Talla reservoir and aqueduct. These works take their name from the Talla Water, one of the tributaries of the River Tweed near its source in Peeblesshire, and comprise an earth dam with a puddled clay core wall, 80 ft. high and 1,050 ft. long at high water line, and an aqueduct about 35 miles long, including 9 miles of tunnel and about 12 miles of concrete aqueduct, the remainder being cast-iron piping.

Practically the whole catchment area of 6,180 acres, which is mainly hill pasture with about 440 acres of peat, was acquired by the trustees of the water-works, who are thus able to protect the tract from pollution. The site selected was naturally very favorable for the construction of a reservoir. The surface area is 300 acres, the length is 2½ miles, and the depth at the dam is 80 ft. A bend in the gorge about 1,200 yd. above the embankment shelters the greater part of the latter from the full force of the waves. The elevation of the site is such that a large area varying between sea level and nearly 600 ft. above Ordnance datum can be supplied by gravity. One important drawback to the site was the absence of either reliable clay for puddle or sound stone for masonry. The nearest point where a sufficient quantity of clay suitable for puddle was found was on the same side of the River Tweed as the proposed aqueduct and about 9 miles from the embankment. The surface and grade of the public roads between the clay bank and the reservoir were unsuited for carting large quantities of material, and a standard gauge railway was therefore built for this service. This road was substantially built with 75-lb. rail and cost, including a number of bridges and considerable length of reinforced concrete retaining well, about $300,000. It has been of great service in delivering all kinds of material and apparatus to the reservoir and to the cross roads leading to various points along the line of the aqueduct. The construction of this railway required about 2½ years and when it was nearing completion the reservoir contract was awarded.



Section of the Talla Dam of the Edinburgh Water-Works.

The general form of the embankment and the relative proportions of clay puddle, adhesive clay material and loose rock fill are shown in the accompanying cross-section. The sill of the waste weir is 950 ft. above Ordnance datum and when filled the reservoir has a total capacity of about 2,800,000,000 imp. gal., including about 160,000,000 imp. gal. below the level at which water can be drawn off to the aqueduct. The top of the embankment is 7 ft. above high-water level and is 20 ft. wide. The greatest depth of the puddle trench below the surface of the ground is 82 ft. The puddle wall is 10 ft. wide at the top of the embankment and its maximum width at ground level is 32 ft. The contents of the embankment, including puddle, facing and soiling, are about 500,000 cu. yd. From the top of the embankment to 10 ft. below high water level the face is protected with 12-in. squared blocks set on 12 in. of broken stone; below the squared stone facing there is a facing of 12 in. of rubble to an elevation of 30 ft. below high-water; and the remainder of the slope is covered with 18 in. of gravel.

The reservoir contract was let in April, 1897. It was originally intended to dispose of the flood waters by a culvert across the line of the embankment near the course of the Talla Water. Later this plan was modified and, instead, a tunnel about 400 yd. long, lined with brick with a concrete invert, and measuring in general 15ft. x 13 ft., 6 in. inside, was driven on a roughly V-shaped course through solid rock around one end of the embankment. While the tunnel was being driven, some progress was made in stripping the site and excavating the puddle trench by erecting a timber flume across the trench to carry the Talla Water. This flume, which was about 15 ft. wide and 3 ft. deep, handled the flow successfully until a period of heavy rains occurred, when the trench was flooded and operations were consequently delayed for about 8 months until the tunnel was completed, in May, 1899.

The excavation of the puddle trench was attended with considerable difficulty owing to the unstable character of the material above the rock surface. It was found necessary to increase the width of the trench considerably at the top, sloping back the sides above the rock surface. A cableway was erected across the valley along the line of the center of the embankment with a span of 1,500 ft., and this was used for removing the excavated material and depositing the puddle. The clay was delivered on the hillside at one end of the embankment. where it was worked into proper condition by hand and then deposited either by the cableway or by timber chutes. The cableway load was about 2 cu. yd. and 70 cu. yd. of puddle in place was considered a good day's work. When the clay could be chuted directly from the storage pile to place, each chute was found to be capable of delivering about 90 cu. yd. per day.

Practically all the material in the embankment, except the puddle for the wall, came from the reservoir site below high-water level and its excavation therefore contributed to the storage capacity. The material was excavated by steam shovels and brought up to the embankment by locomotives handling 4 to 5-yd. cars. The cars were emptied on the surface of the embankment and the material was spread out in layers, the tracks being shifted from side to side as occasion required, thus at the same time contributing to the consolidation of the material.

The by-pass tunnel before mentioned forms a part of the outlet works of the reservoir. When the reservoir works had progressed far enough to permit the storage of some water, a brick plug 18 ft. long was built in the tunnel lining surrounding two 36-in. pipes, one above the other, the upper pipe being provided to carry the water-works supply and the lower pipe as an outlet for compensation water for the Tweed and Talla, required by the Parlimentary act under which the works were constructed.

A wall of stop-planks and puddle about 5 ft. high was built in front of the plug and a plank flume was provided to carry the flood water from the top of this wall beyond the site of the plug.

The valves were then set and the compensation pipe was put in place. The brickwork was then begun and carried up to the level of the bottom of the 36-in. supply pipe; before the latter was set, the wooden flume was removed and the water flowing over the stop-planks was allowed to pass away through the compensation pipe. Several times the latter proved insufficient to handle the water which rose and overflowed the brickwork, necessitating the rebuilding of several courses. After the supply pipe had been placed, the stop-planks were removed and with the additional waterway provided by the second pipe no further trouble was experienced. The inside half of the plug was keyed up first and this allowed putting an additional head on the two pipes and thus increasing their capacity. The plug has proved entirely water-tight with a head of more than 80 ft. upon it. A second plug was built in the tunnel near its middle point to enable the water to be controlled in the event of any accident happening to the first plug or the pipes and valves between the two plugs. All the valves are worked by hydraulic power and most of them are made entirely of gun metal.

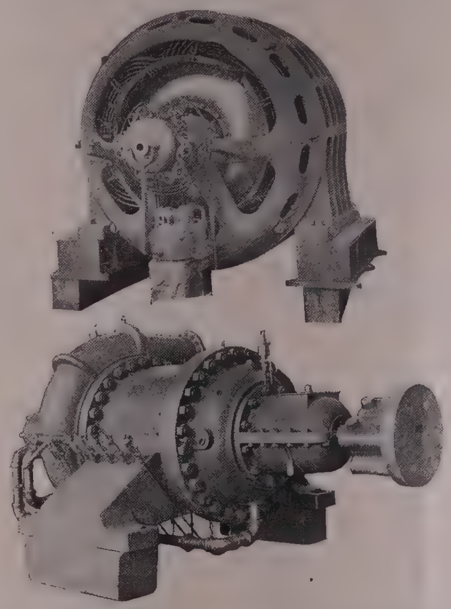
As has been indicated about 9 miles of the aqueduct is in tunnel. At first it was proposed to line only portions of the tunnel, but much of the rock encountered lay on a fairly steep angle and the use of explosives shattered it so that falls from the roof occurred frequently. To avoid future trouble from this source, all the tunnels were lined throughout, some with brick and others with concrete, depending upon the nature of the material. According to Mr. Wm. A. P. Tait, from whose paper read before the Institution of Civil Engineers these notes have been taken, a marked objection to concrete lining in small tunnels through soft ground is the practical difficulty in preventing cavities from being left outside the lining, which may result in subsidence of the ground, setting up uneven strains in the lining. Mr. Tait believes that brickwork, though considerably more expensive, is in very way much more reliable than concrete for such a purpose. With brickwork there is, of course, less difficulty in removing temporary timbering, but one important drawback to its use in a small tunnel is that unless work is prosecuted in several headings simultaneously, there are long intervals when the bricklayers are idle.

The total amount expended for the Talla waterworks, up to the latter part of 1906, according to Mr. Tait, was about $6,250,000, including structures, land, right-of-way, engineering, inspection and various parlimentary and legal expenses. The aqueduct cost about $3,750,000 and at the rate above mentioned had already carried water at the rate of 11,000,000 imp. gal. per day. No opportunity had then been afforded for testing it to its full carrying capacity, the latter being limited by a number of cast-iron siphons varying from 27 to 33 in. in diameter. The typical tunnel section is 6 ft. wide and has a maximum height of 7 ft., 9 in., with vertical side walls 5 ft., 9 in. high and an arched roof.

The new works were designed by, and constructed under, the direction of the firm of Messrs. J. & A. Leslie & Reid, civil engineers, of Edinburgh; Mr. G. H. Hill was consulting engineer for the reservoir. Messrs. James Young & Sons, of Edinburgh, constructed the railway and built a part of the reservoir when the death of the senior member of that firm brought about the re-letting of the reservoir contract. It was completed by Mr. Best, of Edinburgh and Leith, who was already the contractor for about 14 miles of the aqueduct. Messrs. Roberts, McAlpine & Sons, of Glasgow, constructed about 10 miles of the aqueduct and the remainder was built by the trustees of the water-works or by other contractors.

The New York City Fire-Protection Water System.

The high-pressure water system of New York City, now practically completed, is designed to protect the so-called dry-goods district, which extends north from the City Hall to 25th St. and east from the North River to Second Ave. and East Broadway. The system comprises about 63 miles of extra heavy cast-iron mains from 12 to 24 in. in diameter and two pumping stations with a combined present capacity of 30,000 gal. per minute, delivered at a pressure of 300 lb. per square inch. By the addition of more pumping machinery, for which room has been left, the combined capacity of the two stations can be increased to 48,000 gal. per minute and if necessary a third pumping station can be put in service, the pipe system having been designed with this in view. As explained in the report of Mr. I. M. De Varona, chief engineer of the Department of Water Supply, Gas and Electricity, in The Engineering Record of March 22, 1905, the pumping plants are arranged to take either salt water from the North or East river or fresh water from the city mains, the change from one to the other being possible at a moment's notice.



Motor and Pump for High-Pressure Water System.

The pumping stations are outside the district of high fire risk, one being near the Gansevoort market on the North river and the other on the corner of Olive and South streets near the East river. The buildings are of brick and steel fireproof construction with concrete foundations and have as a further protection a complete system of water curtains. Each station will contain five pumping units with room for three more. As the two stations are practically alike in arrangement and equipment, only the one on Gansevoort street will be described and illustrated.

The Gansevoort street building is 63 ft. 8 in. by 97 ft. 4 in. and one story and basement high except along one side where an enclosed two story and basement section is provided for the switchboard and switchboard apparatus. Special care has been taken to make the appearance of the building, both exterior and interior, attractive. The exterior walls are of red brick with terra-cotta and limestone trimmings and the interiors is finished with buff pressed brick with a slate baseboard. The roof is of concrete and is supported by four steel trusses which span the entire width of the building. The foundations and floors are of concrete, the pump room floor being finished with tesselated pavement.

The pumping units are arranged along both sides of the longitudinal axis of the main part of the building on the main floor as shown in the accompanying floor plan. The main suction and delivery pipes are in the basement. The feeders and all other wires enter the building through the basement of the switchboard gallery section, the latter being practically isolated from the rest of the building. On the first floor of the gallery section, which is at the same level as the pump room floor, are the main line and main motor switches, all of which are of the oil-break, remote-control type, installed in standard fireproof brick compartments with fireproof doors. The operating switchboard is in the common wall between the gallery and the pump room so that an operator standing on the pump room floor can control all the station apparatus. The bus bars will be placed in fireproof compartments on the second floor of the gallery section. As before indicated the ultimate installation will consist of eight pumping units, five of which are to be installed at present.

The pumps are of the horizontal multi-stage centrifugal type, each pump having six stages and being able to deliver 3,000 gal. per minute against a discharge pressure of 300 lb. per square inch, when operating at about 750 r.p.m., with a suction lift not exceeding 20 ft. Under these conditions the specifications require the efficiency of each pump to be not less than 70 per cent. The pumps are designed so that the discharge pressure can be varied between 100 and 300 lb. by means of a special regulating valve. This type of pump was chosen because of its simplicity and the small space required for the pumps and motors.

The impellers, diffusion vanes and other internal parts are made of bronze composition, made up of 88 per cent. copper, 10 per cent. tin, and 2 per cent. zinc. The casing is of cast-iron lined with brass and is designed so that the impellers may be removed without entirely dismantling the pumps.

Though the pumps are water balanced, special provision is made for end thrust by a ball bearing with two rings of 1-½ in. balls in the outboard bearing. The bearings are of the ring-oiled type and are separated from the pump casing by packing glands which prevent foreign matter from entering the bearings. All parts of the runners and diffusion vanes are thoroughly lubricated by oil cups on the base of the pumps, shown in an accompanying illustration. A special feature is the wide base which brings the pump barrel as low as possible and gives stability. The pumps were supplied by the Allis-Chalmers Co. and are believed to embody the best features of present practice in the design and construction of such machines.

Each pump is direct connected to its motor by a special flexible coupling designed to take care of any possible variation from perfect alignment. The motors are of the constant-speed induction type, 3-phase, 25-cycle, 6,300 to 6,600-volt, 800-h.p., designed to operate at about 750 r.p.m. Their full load efficiency is approximately 93½ per cent.; the full load power factor is approximately 94 per cent.; and the slip at full load is approximately 1 per cent. The motors are of the wound rotor type and in starting an iron grid resistance is connected in the secondary circuit and gradually cut out by means of a hand wheel installed on the motor switchboard panel. When the resistance is all cut out the rotor is short circuited by means of specially constructed solenoids which are all controlled and operated from the main motor panel by means of auxiliary switches. These controllers and motors are so designed that they can be brought up from a standstill to full speed in approximately 30 seconds. An interlocking arrangement is provided with the controller device, arranged in such a manner that the motor cannot be connected to the line when the rotor is short circuited.

The electric current for the stations will be supplied by the New York Edison Co., at a pressure of 6,600 volts. The company has six generating and distributing stations in the city; it also has feeders connecting with the Brooklyn Edison Co., which can supply additional current if required. Each pumping station will have two 250,000 C. M., 3-phase cables laid in ducts running from the main generating station of the Edison Co. In addition to these cables there will be two independent reserve feeders running to each pumping station from sub-stations of the Edison Co. An interruption of the current supply will thus be practically an impossibility.

The salt water supply will be taken from a reinforced concrete suction chamber near the south end of the station building and about 660 ft. from the North river bulkhead line. This suction chamber was described in detail in The Engineering Record of December 15, 1906. It is connected with the North river by two parallel 36-in. cast-iron mains; a reinforced concrete screen chamber, also described in the issue of December 15, 1906, prevents the entrance of debris. The intake mains have their tops about 2 ft. below mean low-water level at the bulkhead and fall toward the suction chamber slightly to facilitate their being emptied when this is necessary. The bottom of the suction chamber is about 2¾ ft. below the inverts of the intake pipes. Two 30-in. suction pipes, which are reduced to 24 in. inside the station, begin at a point 2 1/3 ft. above the floor, and turning with 90 deg. elbows enter the station basement horizontally. As the elevation of low water in the river is about 6 ft. above the suction chamber bottom, the suction pipes will always be submerged at least 3½ ft.

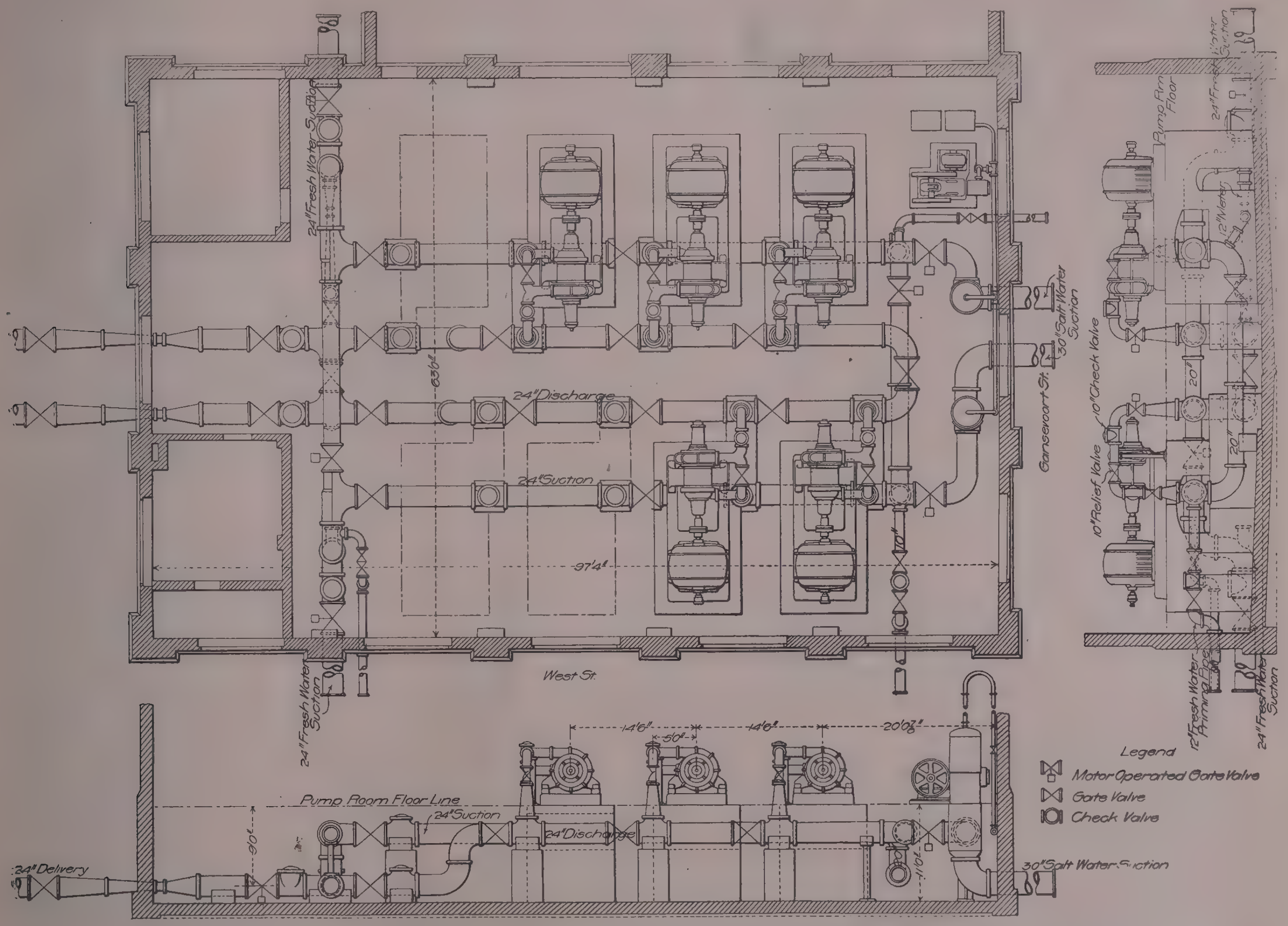
In order that there may be no delay occasioned by priming the pumps when they are to handle salt water, three vacuum pumps are provided, each of which when working singly can prime the suctions and maintain constantly for the eight pumps a vacuum of at least 26 in. of mercury. Two of these pumps are of the self-oiling, two-cylinder, single-acting type, having a piston displacement of about 50 ft. each, when working at a piston speed of 160 ft. per minute. Each is geared to a direct-current motor, the unit in each case being self-contained. The third pump has a displacement of 300 ft. per minute, working at a piston speed of 300 ft., and has mechanically-controlled intake valves. This, too, is self-contained with its motor.

Connected to the highest point of each salt water suction line is a cylindrical air chamber, with a capacity of about 130 cu. ft., in which the entrained air and gases in the water will be collected so that the suction to the main pumps can be maintained at all times. Each air chamber is equipped with a gauge glass and vacuum gauge. The priming apparatus is so designed so that any one or all three of the air pumps can be operated in connection with either of the air chambers. By an automatic device one of the smaller pumps will be set in motion when the water in the air chamber falls below a predetermined level; similarly, the large vacuum pump will be put in operation automatically when the water falls below a second predetermined level, indicating that the smaller pump cannot maintain the required vacuum. The second small vacuum pump will be held in reserve for use in special emergencies. The main pumps can also be primed with fresh water taken from the city water distribution system through the 12-in. pipe shown on the accompanying plan.

The fresh water supply for the Gansevoort station is taken from a number of large mains of the city water supply system varying in size from 20 to 48 in., cross-connected by a 36-in main from which two 24-in. pipes lead into the north end of the station. In the station basement a 24-in. suction line extends longitudinally under the pumps at each side of the building. These pipes are cross-connected at each end of the basement with a 20-in. pipe equipped with a motor-operated gate valve. A 24-in. motor-operated gate valve is placed just outside the suction loop on each of the five supply pipes and 24-in. manually-operated gate valves are arranged on both suction and discharge mains as shown on the plan. The 24-in. discharge main forms a loop, the ends of which leave the building at the north end, where a 24-in. motor-operated valve and a Venturi meter with a recording instrument is introduced in each line.

The suction end of each pump is connected to the suction main by a 24-in. pipe which gradually reduces to 10 in. at the pump, where a 10-in. gate valve is introduced. Each pump discharges through a 10-in. check valve and a 10-in. motor-operated gate valve into a pipe which increases to 20 in. at its connection with the main discharge West street station line. The valves are introduced to facilitate the isolation of the pumps from the system and prevent back flow from the delivery pipe into the suction main. Tees are provided in the pump suction and delivery pipes to connect with the station bypass.

The contract price for the Gansevoort and West streets station building was $69,527.00 and the contract price for the Oliver and South streets building was $71,344.00. The contract price for the salt water suction mains for the two stations was $63,652.00.



Plan and Sections of the Gansevoort Street Pumping Station, New York High-Pressure Water System.

The 24-in. discharge mains leading from the two pumping stations bound almost the entire protected area. In the streets paralleling and intersecting the 24-in mains, 16 and 24-in. pipes are laid, cross-connected with 20-in. mains. All the mains are connected at every intersection to make the circulation as nearly perfect as possible, and the water will in no case have to travel far in a main smaller than 20 in. before it reaches a hydrant. Gates are placed at the end of every block on all except very large pipes where the gates are two blocks apart. There are always hydrants within 400 ft. of any building in the district and there are enough hydrants so that if any block were on fire 60 streams of 500 gal. per minute each or the full capacity of both stations could be concentrated on a block with a length of hose not exceeding from 400 to 500 ft., assuming the use of 3-in. hose and 1¼-in nozzles.

Two shifts of attendants will be maintained at each station, each shift consisting of one engineman, one oiler, one switchboard operator, and two laborers. When the stations are put in service special pains will be taken to secure an accurate record of the service rendered. The amount of water delivered to every fire, the pressure maintained, the power used and kindred data will be recorded.

The mains are designed to withstand a regular working pressure of 300 lb. per square inch and are very heavy. The joints are of special form, and there are deep double grooves in both the spigot and the hub ends. The special castings for the large three-way and four-way branches are made of steel with a very large factor of safety. The other specials are cast-iron and are also designed with a large factor of safety. The gates are of cast-iron and have nickel steel stems which combine great strength with freedom from corrosion. All other working and bearing parts are of bronze composition. All gates, 12 in. and larger, are fitted with by-passes to relieve pressure on the disc and all gates have flange ends with a short spigot piece bolted to the gate so that in case of a break the gate can be removed and a new gate substituted very quickly. The pipes, specials, hydrants and the like, were described in the issue of The Engineering Record of March 25, 1905. The requirements for the hydrants are so important that some of them are repeated here.

The more important requirements for the hydrants are that the main valve shall be designed so that the pressure of the water will tend to close it; that bronze shall be used for all metal parts of the valve and valve seats; that no movable iron parts shall come in contact with cast-iron; that there shall be four nozzles, one 4½ in. diameter and three 2½ in. in diameter; that all outlets shall be controlled by independent valves of composition with rolled nickle steel stems; that the clear water-way through the main valve shall be not less than 28 sq. in. and the internal diameter of the standpipe not less than 9 in.; that the inlet at the base of the hydrant shall be 8 in. internal diameter and flanged; that the hydrant shall be designed so that all valves seats, spindles, etc., can be removed without disconnecting the hydrant; that the main valves can be opened and closed by one man, using a 15-in. wrench when the hydrant is under the maximum working pressure of 300 lb. per square inch; that the fire-boat connection hydrants shall have two 3½-in. fire department standard female connections to fit with the fire-boat connections; that each hydrant shall be tested under 300 lb. and 600 lb. pressure, both with the main valves opened and with the main valve closed and with the independent valve closed; that the hydrant shall be perfectly tight under 300 lb. pressure and not show a greater leakage than ½ oz. per minute under 600 lb. pressure. The fire-boat connections will be located on the river front at points where they can render the best service and on the ends of piers when practicable. A double female swivel increaser is provided for the use of the fire-boats in connecting their larger hose with the smaller nozzle of the hydrants on the docks.

In order to save time in transmitting orders to the engineer at the pumping stations concerning the pressure and amount of water required and the like, a system of telephone signal boxes is being installed, placed so that a fire in any part of the district can be watched from at least one of these signal boxes.

The construction of the distribution system has involved some very difficult work owing to the large number of public service pipes of various kinds already in place in the congested lower part of Manhattan Island. At the intersection of Tenth street and Fourth avenue, a particularly difficult situation was encountered. Here a 12-in. high pressure main in Tenth street in crossing Fourth avenue had to be carried around a Rapid Transit Railway manhole, over or under 17 other pipes, and under a double-track street car line. Nine pipes varying from 4 to 10 in. in diameter and placed at various depths were on the west side of the car line in a strip about 15 ft. wide, and eight pipes of similar sizes and similarly placed were on the east side of the tracks. Some of these pipes were raised and others were lowered and the high pressure main was carried through with about 24 in. of cover. For such cases special curved lengths of pipe are used to lower or raise the pipe line quickly. In Fourteenth street for half a block east of Fourth avenue the only space available for the 12-in. high pressure main was along the extreme south side of a double-track street car line, and the concrete track foundation had to be cut under to form the pipe trench. The difficulty was increased by two other pipe lines so close to the track near the surface of the street that several lengths of the high pressure pipe had to be rolled into the trench whence it was more open and pulled into place under the old lines.

As there will be ordinarily little or no flow in the mains, they are now laid in general with their tops at least 5 ft. below the surface of the street or about 1½ ft. below the frost line. Where the pipes are brought near the surface, special arrangements are made to prevent freezing and during the winter water will be slowly pumped from one station to the other at intervals as an additional precaution.

Before the mains are covered they are tested in convenient sections with a pressure of 450 lb. per square inch. Most of this testing has been done with a portable power outfit, consisting of a four-cylinder, single-acting, high-pressure pump, made by the Chas. Burroughs Co., driven through a gearing by a Nash gas engine, the two machines being mounted on a special four-wheel horse truck.

The New York high-pressure system was designed by Mr. I. M. de Varona, Am. Soc. C. E., chief engineer of the Department of Water Supply, Gas & Electricity, who also designed the high-pressure fire systems for Brooklyn and Coney Island, and under whose supervision the construction work is carried on. Mr. Thomas J. Gannon, engineer in charge of the mechanical division, has had charge of the preparation of plans and specifications for the pumping machinery, electrical motors and appliances. Mr. Henry B. Machen, Asso. M. Am. Soc. C. E., assistant engineer, has had direct charge of the contracts for furnishing, delivering and laying the distribution mains. Mr. John P. Reynolds, Jr., Jun. M. Am. Soc. M. E., mechanical engineer, has had charge of the construction of the pumping stations and the salt water suction intakes.

The Allis-Chalmers Co. is contractor for all the pumping station machinery and appliances, the contract price for the plant at each station being $199,635.50. The work of constructing the distribution system is divided into three contracts. The Continental Asphalt Paving Co. was the lowest bider on the three sections and was awarded the contracts, the total contract price for the three sections being $2,824,282.75.

Tests of Reinforced Concrete Beams at the University of Illinois.

The series of tests of reinforced concrete beams which was made in 1906 at the Engineering Experiment Station of the University of Illinois, under the direction of Prof. A. N. Talbot, is explained in a bulletin by him that has just appeared. All beams were 8 x 11 in., with the center of the steel reinforcement 10 in. below the top surface, except in some cases where the ends of the bars were bent up. Plain round rods of mild steel were generally used for reinforcement, but deformed bars were used in a few cases, they amounted to 0.98 to 2.21 per cent. of the section. A 12-ft. span was used in all tests, except those where the resistance to diagonal tension failure was sought, when the test span varied from 6 to 12 ft. Well-graded and fairly clean river sand was used, which weighed 115 lb. per cubic foot loose and contained 28 per cent. of voids. Part of the cement was a mixture of five standard American Portland cements of excellent quality, and part was bought in the local market, having a strength in neat briquettes of 680 and 891 lb. at 7 and 60 days and of 242 and 404 lb. in 1:3 mortar briquettes at 7 and 60 days. Two grades of crushed limestone were used. The first passed a 1-in. screen and was caught on a ¼-in. screen; it contained 45 to 50 per cent. of voids and weighed 85 lb. per cubic foot loose. The second was of the same size, but somewhat softer and contained from 50 to 54 per cent. of voids. The proportions of the concrete varied from 1:2:4 to 1:5:10 by loose volume. The beams were well made in most cases, but in a few of them dry stone was used, insufficient water was added and the concrete was allowed to become too dry. The beams were tested when about two months old in a 200,000-lb. machine, the load generally being applied at the one-third points. Center deflections were read on all the beams, and the deformations of the upper fiber and steel were measured by four extensometers.

Effect of Quality of Concrete. In this series tests were made on beams of 1:2:4, 1:3:5½ and 1:5:10 mixtures. The purpose was to determine the effect of quality of concrete on the strength of the beam and the manner of failure. The manner of failure for beams of these proportions depends upon the richness of the concrete. Counting the effect of the weight of the beam and loading apparatus, all the beams made with 1:2:4 concrete failed by tension in the steel at calculated stresses somewhat above the elastic limit of the steel. Of the beams of 1:3:5½ concrete all but two failed by tension in the steel. The calculated stresses in the steel, when allowance is made for the weight of the beam, are slightly above the elastic limit of the steel. The two not failing by tension in the steel, when compared by the stresses computed either from the bending moment or the observed deformations, gave stresses in the steel not much lower than the average of the remainder of the series. Both of these beams, therefore, had hardly reached the load which would have been followed by failure by tension in the steel. All the beams made with 1:5:10 concrete failed by diagonal tension at loads which show a rather narrow range, regardless of the amount or method of reinforcement. The vertical shearing unit-stress developed averaged 68 lb. per square inch. As the beams failed by diagonal tension at loads much smaller than those at which failure by compression in the concrete may be expected, there is nothing in these tests upon which to base the limit of the concrete or the amount of reinforcement at which the compressive strength of the concrete and the tensile strength of the steel may be considered to be balanced.

A comparison of beams having 1.1 per cent. reinforcement which failed by tension in the steel shows that the 1:2:4 beams carried 10 or 15 per cent. greater loads than the 1:3:5½ beams. This increase probably is due, Prof. Talbot states, to the fact that the greater strength of the richer concrete allows the steel to be stretched a greater distance beyond the elastic limit before developing the full compressive strength of the concrete and also that the moment arm of the couple formed by the compressive stresses is somewhat greater with the richer concrete.

Effect of Method of Loading. It was the purpose of this series to determine the effect of the method of loading upon the resisting moment developed in the beam. Six methods of loading were used in the tests of this series: (1) Load applied at center of the span only; (2) load applied at two points 1½ ft. apart; (3) load applied at two points 3 ft. apart; (4) load applied at the one-third points; (5) load applied at two points 7½ ft. apart; (6) load applied at eight points (to approximate a uniform load).

All beams failed by tension in the steel. If the effect of the weight of the beam and loading apparatus is included, the calculated stresses in the steel all lie above the elastic limit. The highest stress developed was in beams having the loading at the middle, and when the two loads were close to the middle the results were not much lower. For the other methods of loading the variation in stress developed was not large, no greater than may be expected with the difference in the materials and fabrication in such beams, though the method in which the load was applied at eight points gave a somewhat higher resisting moment. These tests go to show, Prof. Talbot states, the general applicability of the ordinary beam theory to simple beams without end restraint or horizontal restraint for any of the usual methods of loading, with the exception of center loading, provided, of course, the proportions of the beam are such that the method of failure is by tension in the steel. The beams loaded at the middle give about 10 per cent. greater resistance than the more usual methods of loading. This excess is not so great as has been found in beams having a high percentage of reinforcement. With high reinforcement the resulting moment developed is considerably greater than for loading at the one-third points. Evidently under such conditions loading at the middle gives a distribution of stresses at sections near the center of the beam, which is different from that assumed in the ordinary theory of flexure.

Effect of Repetitive Loading. Tests were made on six beams to determine the effect of repeatedly applying and releasing the load on the beam, from 24 to 30 applications of a single load being made. Three mixtures of concrete were used, thus permitting a study of the effect of quality of concrete. All beams were reinforced with 1 per cent. of steel. The load applied was 5,000 lb. in three beams and 6,000 lb. in the other three. These loads were from 50 to 85 per cent. of the maximum load carried by the beam when the load was finally increased to the point of failure. The deflection at the midpoint of the span was measured, as were the deformations at the top and bottom for a gauged length along the middle of the beam, though the latter measurements were not entirely satisfactory.

These tests throw light upon the phenomena of repetitive loading and show the need of further investigation in this direction, but they are not at all conclusive, Professor Talbot states. The manner of failure in general is the same as may be expected with beams of the same reinforcement and same quality of concrete loaded progressively to final failure. Whether the maximum load carried in the case of the repetitive loading is less than would have been the case with progressive loading is not known. There are some indications that the maximum load was less than it would have been without repetition.

The increase in the deflection of the beams with repetition of the load is quite apparent. Much of this increase is due to the increased amount of shortening of the concrete in the compression side of the beam with repetition. A part is due to the breaking of the concrete in tension and the transferring of the tensile stress once taken by the concrete to the steel itself. This accounts for part of the set in the deflection curve upon the release of the load. Part of the set must be due to the concrete in the lower fiber not meshing, so to speak, when the load is released after numerous fine cracks have appeared. For this reason some tension remains in the steel reinforcement after the load is taken off. It seems evident that upon the removal of the load the beam does not regain its original shape, and a section which was plane before bending will not be plane upon release of the load. The plastic nature of the concrete on the compression side gives a set, and the concrete on the tension side is unable to return to its original position; the two act together to cause the fibers not to return to the original plane section. These several causes operate together to produce the permanent deflection or set.

The load applied in the cases of the leaner concretes was 67 to 85 per cent. of the maximum load which the beam finally held. In the case of the better concrete the repeated load was 50 to 60 per cent. of the maximum load.

Diagonal Tension Failures. Certain secondary stresses or web stresses exist in the concrete, in addition to the horizontal or longitudinal tensile and compressive stresses which are always considered in the analysis. Strictly speaking, the shearing stresses developed under ordinary conditions are relatively light, and the actual shearing strength of concrete is considerably greater than the shearing stress which exists in ordinary beams at the time of failure. It is quite common, however, to use the term "shearing failure" as a name for a class of failures in the web of a beam, but it must not be understood from this use of terms that the failure necessarily involves actual failure by shear. Generally speaking, such failures are due to the inability of the concrete to resist the tensile stresses developed in the web in a diagonal direction, and the term "diagonal tension failure" is a much more appropriate name for this form of failure. It is a principle of mechanics that where shearing stresses exist tensile and compressive stresses are set up at an angle with the direction of the shearing stresses. If longitudinal tensile stress also exists in the concrete the diagonal tensile stress induced by the combination of these with the shear is even higher than that due to shear alone. If v represents the horizontal and vertical unit-stress at any point in the web of a beam and s the horizontal tensile unit-stress existing in the concrete at the same point, then the formula for the maximum diagonal tensile unit-stress is

$$t = \tfrac{1}{2} s + \sqrt{(\tfrac{1}{4} s^2 + v^2)}$$

If there is no longitudinal tension in the concrete this formula reduces to $t = v$, and maximum diagonal tension makes an angle of 45 deg. with the horizontal and is equal in intensity to the vertical shearing stress.

It is evident that the amount of this diagonal tension is dependent upon both the shearing stress and the longitudinal tensile stress in the concrete at the point considered. The amount of longitudinal tension is not easy to determine, and hence the actual amount of the diagonal tensile stress is uncertain. The best method for ordinary computation seems to Prof. Talbot to be to compute the vertical shearing unit-stress and make all calculations upon the basis of this value. The value of the vertical shearing unit-stress, where the longitudinal reinforcement is straight (not bent up or inclined) may be computed from the formula $v = V/bd'$, where V is the total external vertical shear at the section considered, b is the breadth of the beam, d' is the distance from the center of the steel to the center of the compressive stresses. For beams with 1 per cent. reinforcement d' is about $0.86d$, d being the distance from the center of the steel to the upper face of the beam.

The value of v thus calculated for beams which fail by diagonal tension ranges from one-half to one-third of the tensile strength of the concrete. Diagonal tension failures are frequently characterized by sudden failures without much warning, as is the case in the failure of plain concrete beams. A variation from this gives a slower failure, part of the shear being carried through the reinforcing bars, and the ultimate failure involving the splitting and stripping of the bars from the beam above. When the reinforcing bars are bent up or inclined toward the ends of the beams the distribution of the vertical shear is different from that just outlined and the analysis is more complex.

The range of the values of the vertical shearing unit-stress v, in pounds per square inch, found in these tests with beams having the reinforcing rods in a horizontal position may be summarized as follows, the results being obtained with a single application of the load on beams about 60 days old:

Concrete.	Range.	Average.
1:2:4	136 to 142 lb.	139 lb.
1:3:6	92 to 115 lb.	99 lb.
1:3:6*	55 to 83 lb.	69 lb.
1:5:10	63 to 74 lb.	68 lb.

*Poorly made concrete.

The one beam of 1:4:7½ concrete which failed in this way gave 43 lb. per square inch. This beam was subjected to repetitive loading. These results show the importance of using a rich concrete in the web of reinforced concrete beams which are subjected to any considerable amount of diagonal tension when there is no metallic web reinforcement or when the web reinforcement is not effective. Professor Talbot considers that it is probable that not enough attention has been given to this element in the design of short and deep beams.

Generally speaking, the crack when first observed extended from the bottom of the beam to the steel reinforcement and from the steel reinforcement diagonally a short distance toward a load point, although in some cases the diagonal crack was observed before the vertical crack was visible. Sometimes this diagonal crack was observed before the maximum load was reached and sometimes not until the maximum load had been passed, or even until after the beam had failed quite suddenly. In some of the beams the diagonal crack was seen to extend forward slowly toward the load point, before or just after the maximum load was reached, and then a horizontal crack grew along the level of the top of the reinforcing bars toward the support.

The phenomena of final failure were frequently connected with the slipping of the reinforcing bars or with the stripping of these bars from the concrete above. The slipping of the bars which occurred was not observed until the maximum load had been passed, and generally in these cases the crack also extended along the bars. It seemed evident to the observers that this slip did not occur before the maximum load was applied and before the existence of the diagonal crack had materially modified the conditions in the beam. In all the cases where slipping of the bar took place the action extended progressively from the diagonal crack toward the load point, though in some cases this action was quite sudden. From all the information available it seems to be evident that, whatever slip of the bars may have taken place, the slipping did not exist before the time of the maximum load and resulted from the changed conditions incident to the formation of the diagonal crack. It therefore seems evident that the failure of these beams should be credited to diagonal tension.

In the case of beams with the reinforcing bars bent up or inclined in the outer two-thirds of the length of the beam, the vertical portion of the crack from the bottom of the beam to the reinforcement formed first, and was due to the failure of the concrete in tension. The diagonal crack then grew toward the load point, generally forming before the maximum load was reached, and the growth of the crack along the reinforcing bar generally followed. It was expected that this method of bending up bars would give a higher value for the vertical shear, as calculated by the equation, $v = V/bd'$, in beams failing by diagonal tension than that found in beams with the bars horizontal, but in this the results were disappointing. In a few beams the values ran higher. In the phenomena of failure it appeared that the element of slip was present, though it is not known that this slip occurred before failure. Calculations indicate that the bond stress developed at the end of the bars must have been considerable. It should be noted that none of the bars were anchored at the ends.

In the case of the beams in which failure occured by tension in the steel or compression of the concrete, the dimensions of the beams were such that the diagonal tension developed (as measured by the vertical shear) at the time of failure was less than was found with beams which failed in diagonal tension, and hence that the strength of the concrete in diagonal tension had not been reached.

In six beams U-shaped stirrups of ½-in. mild-steel round rods were placed in a vertical position and enveloped the horizontal reinforcing bars. The longitudinal spacing was inadvertently made 12 in. It is clear from the results of the tests that the spacing of the stirrups in these beams caused them to be inefficient, the distance apart being too great, and, besides, the stirrups were not properly placed in the beam. Further tests are now in progress, in which the dimensions of the beam and the size and spacing of the stirrups are expected to bring out the effectiveness of this method of web reinforcement.

The Commercial Motor Vehicle has been long studied and tested by the Studebaker Co. of South Bend, Ind., the well-known builders of all types of horse-drawn vehicles for pleasure and business. The company has been building successful electric cars and high-grade automobiles for some time, and it has now become convinced that the motor-truck for commercial purposes is to attain early and great popularity. In order to avoid hasty judgment on this subject, Mr. Hayden Eames advises those contemplating purchasing such trucks to make their comparative estimate in the following manner. First make an absolutely complete ledger statement of what it costs to do the work currently with horses, including rent of stable space, insurance, interest on investments, and every part of a financial accounting. Then, having obtained a thorough knowledge of precisely what service is required, and what the limitations of that service are, proceed to draw up specifications for a corresponding power wagon installation, or organization, to do the same work. Having done this, prepare an accurate ledger statement of the expected performance of this second installation, and compare the two. Unless the comparison is made in this way it will be misleading.

Book Notes.

Dr. Alfred E. Phillips, professor of civil engineering at the Armour Institute of Technology, has prepared a manual of "Surveying" which gives in a clear form practical instruction in the use of surveying instruments and the method of plain surveying, including plotting, levelling, triangulation, line running, cross sectioning, traversing and other details of field work. The information is given in a clear manner with excellent illustrations. (Chicago, American School of Correspondence, $1.50.)

The Blue-book issued by the last Royal Commission on Sewage Disposal forms a repository of information on the subject of the highest value. Unfortunately the great mass of facts and opinions in this report is so arranged that it is difficult to utilize it readily, and, moreover, the volumes are not readily accessible to American engineers. Consequently a digest of the information in Parts 1 and 4 of the report, prepared by Mr. Herbert Scoble, under the title of "Land Treatment of Sewage," is a valuable reference book. Sewage disposal has received more general attention in Great Britain for a longer period of time than in any other country, owing to the local conditions which made some system of disposal necessary for most towns and cities. The book gives a summary of the testimony relating to irrigation, chemical treatment, and later biological systems. Although the volumes of which the book is a digest were issued in 1904, the information is practically up-to-date and authoritative. (London, St. Bride's Press, 5 shillings.)

Some years ago, Prof. Edwin P. Seaver, of Harvard University, prepared a collection of the formulas and rules of trigonometry as a syllabus for instruction in his classes. After serving its purpose, it went out of print, but a copy found its way to the desk of a leading civil engineer, who found it so constantly useful that he urged the author to enlarge the work. Accordingly the author has prepared similar synopses of algebra, the differential and integral calculus, and analytic geometry, and the complete collection has been published as the "Mathematical Handbook," in an admirably printed 8½x5½-in. book of 279 pages. The subject of hyperbolic functions, which now receives much more attention than formerly, has been more fully treated. There are numerous tables to facilitate computations, and the arrangement of the contents has been so ordered as to make the formulas and rules as useful as possible to engineers and others. The book is a substitute for many textbooks in the engineer's working library, and is far more complete than the mathematical chapters of the popular handbooks. (New York, McGraw Publishing Co., $2.50.)

Books on electrical subjects for the attendants of electrical apparatus and for people who have had only a common school education are numerous, and so many of them are unbalanced and unreliable that the whole class is regarded with suspicion by engineers. There is no reason, however, why a book for such readers should not be reliable so far as it goes, as is shown by the "Electrical Engineering" of Chief Electrical Engineer E. Rosenberg, of Koerting Bros., Hanover. This has been translated by Prof. W. W. Haldane Gee and Mr. Carl Kinzbrunner, of the Manchester Technical School, and has been revised for American readers by General Superintendent E. B. Raymond, of the Schenectady works of the General Electric Co. The book originated in a series of lectures to the workmen and staff of the company with which the author was connected. These lectures were intended to furnish the men a general knowledge of the operation of the machines and apparatus they were making, the explanations being stated in an elementary manner before any mathematical formulas were given. No attempt was made to teach the methods of computing the parts of the machines. By thus omitting those mathematical aspects of the subject to which most attention is generally given in lectures for engineers, the author was enabled to explain the operation of continuous and alternating current dynamos and motors, storage batteries, measuring instruments and electric lighting apparatus. The space given to alternating current machines is unusually large, as compared with the skimpy notice generally given them in elementary manuals and is one of the most valuable features of the book. The illustrations show German and British apparatus for the most part, but as the text describes principles and methods rather than the details of machines, the scarcity of illustrations from American sources is not a defect. (New York, John Wiley & Sons, $2.00.)

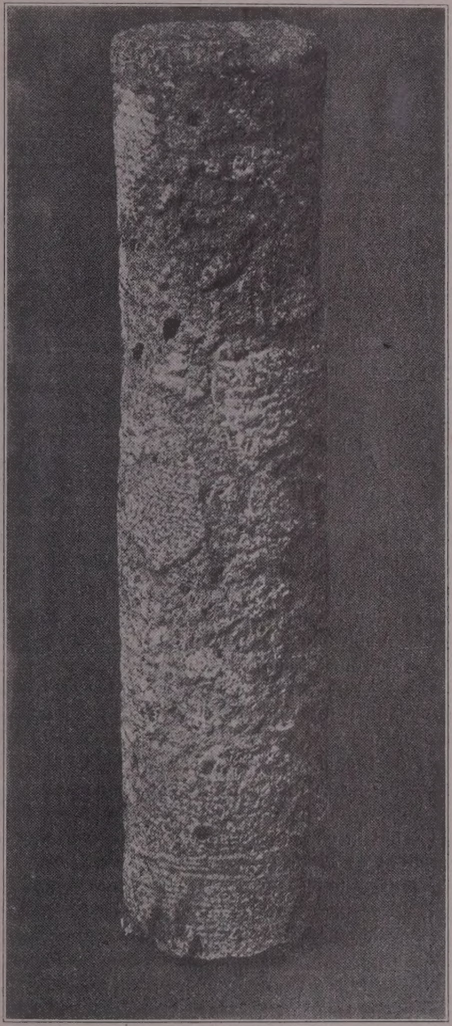
A story of a century's achievements in industrial pursuits, resulting from the spread of technical education, is told in a forceful and comprehensive manner in a memorial volume issued by the Munich Polytechnic School to celebrate the centennial of the assumption of royal rank by Maximilian IV, Elector of Bavaria. The great things the kingdom has done for the fine arts during this period are the theme of innumerable books, but what has been done in engineering and the technical industries is not so well known, although it has been the basis of the country's growth in prosperity. Everybody knows that this growth has been enormous, yet its full extent can only be appreciated by some such general review of technical developments as this volume gives. The book opens with a general statement of the condition of industries a hundred years ago, written by Walther von Dyck, which is followed by an outline of the beginnings of technical instruction in Bavaria, by Siegmund Guenther. The progress in Munich architecture is reviewed by Richard Streiter, and the sanitary conditions in the city at the beginning of the nineteenth century are explained by Martin Hahn. The progress in methods of illumination is described by Ernst Voit. A chapter of special engineering interest, by Siegmund Guenther and Ferdinand Loewe, describes former and present highway construction and gives illustrations of a remarkable mountain road. Another chapter of particular engineering value is Max Schmidt's account of early precise surveys and topographical work. Franz Kreuter and Ernst Henle describe Bavarian hydraulic engineering, and Wilhelm Dietz reviews the progress in bridge building, one of his illustrations showing a wooden arch bridge with two spans, each of 159 ft. (French) span. Other chapters by specialists relate to railways, pumps, astronomical and surveying instruments, the textile industry, paper making, chemical industry, glass, pottery, brewing and agriculture. Taken as a whole the volume is an excellent summary of what technical education has done for Bavaria. (Munich, R. Oldenbourg, 25 marks.)

A book of unusual value to every one interested in works for water supply has recently been written by Mr. Chas. A. Hague, to furnish in language as free from technicalities as practicable a description of the principles upon which pumping engines operate, a brief outline of their development and a detailed discussion of their parts, without taking up the actual computation and drafting-room practice of the designer. The author is well qualified to give this latter class of information, on account of his connection for many years with the manufacture of pumping engines, but he has wisely refrained from doing so and confined his attention exclusively to the preparation of a book equally useful to members of water boards, superintendents of water works and engineering students. The title of the book, "Pumping Engines for Water Works," explains its contents fully. In the historical sketches which form the introductory portion of the volume, the close connection between the history of the steam engine and of water pumping is clearly brought out, and throughout the book the author lays emphasis on the fact that a pumping engine is essentially a combination of a water end and a steam end, which is primarily useful for raising water and depends for its value mainly on its reliability. The frequent repetition of the fact that reliability is all important in pumping engines is to be commended, for considerations of coal economy and low first cost, about which so much is said when a pump contract is up for discussion, fall into second place behind the certainty of constant operation. Yet economic steam duty is highly desirable, and the author discusses it early in the book and follows this discussion with a chapter explaining at considerable length the approach which is made by the best pumping engines to theoretical possibilities. Special attention is called to the examples given by Mr. Hague in his illustrations of this important subject, for they form an exceptionally clear statement of just what steam does in such engines. The chapter on steam jackets brings up a subject which has long been a matter of controversy. The author takes the position that under most conditions enough more steam can be saved by the jackets of pumping engines to make their use profitable. The chapter which follows on the coal duty of pumping engines explains clearly the meaning of this unfortunate and often-misleading term. The fact that it seems to be with us to stay makes the chapter useful, although it is essentially a feature of boiler practice rather than of pumping engine work. The chapter on the actual conditions of pumping is probably one of the best guides for the members of a water-works board, about to place a contract for a pumping engine, that has ever been written. The four chapters that follow describe in considerable detail the development of the Worthington duplex, the Holly quadruplex, the Gaskell and the Reynolds triple-expansion pumping engines. The general classification of pumping engines now on the market is next described, after which there is a chapter on the adaptation of a pumping engine to the conditions to be met in service. The chapter on the installation of pumping engines is probably unique, and unquestionably will make the book particularly useful to designers of pumping stations, for no published information on the subject is now available, and the suggestions in this chapter are based upon a long experience with such work. The chapter on the investment value of pumping engines gives many tables of the cost of pumping, with plants of different classes, and similar information, but throughout the discussion of the subject the author is careful to point out that the figures are averages and must not be applied to any given case without careful previous investigation. The chapters that follow discuss the design of suction pipes, water passages and water valves, water plungers, air chambers, the steam pistons, steam cylinders, cross-heads, frames and bed plates. The selection of material for pumping engines is the subject of a special chapter, and the book closes with an explanation of duty tests of pumping engines. The volume contains information which is not to be had in such convenient form elsewhere; in fact, a large part of it has never before appeared in print, for the author has drawn on his long experience in the pumping engine industry and on information furnished by former associates for much of the special illustrative material which is given. Where topics still the subject of controversy are discussed the author is careful to point out that his opinion may not be held by all, and where the subject involves a balancing of different claims, both sides are stated and the reason for the author's choice is given. The book is far the best work on pumping engines that we have in English at the present time. (McGraw Publishing Co., New York, $5.00.)

Letters to the Editor.

Sampling Concrete.

Sir: In a great many instances where contracts have been completed on concrete work, a question frequently arises relative to whether or not the contractor has fulfilled the specifications in regard to mixture, and other things, and the result is usually a long drawn out litigation. In a great number of cases the work is of such character that to determine whether or not the specifications have been followed is quite difficult. To ascertain in the ordinary way of taking samples by digging into the work, if the samples are to be of any value, it is necessary to obtain them from various sections and from the interior as well as from near the surface. If the work is a heavy arch, wall or foundation, to dig a large hole into it would not only deface it but injure its strength, which would necessarily mean a considerable loss in money and time. The most practical method for accomplishing this result is by sampling the work as a dealer would do a cheese, by taking out a core of the material with what is known as a shot drill. They are made in various sizes, but the small hand power outfits answer the purposes in practically every instance.



A Sample of Concrete.

A hole can be run into the concrete very rapidly, a core removed, analyzed, and the character of the mixture determined accurately. The holes do not injure the strength or appearance of the work. Samples can be taken at any depth desired. The writer does not know if this method of testing concrete was original with the Government, but it was used on the locks and dams on the Ohio River a few years ago, which was the first work of the kind he had seen. The illustration shows a section of a 1¾-in. core taken from the concrete on the Government work. This method, aside from being an absolute check on the contractor, also keeps a check on the inspector who is placed in charge of the work, or saves the cost of an inspector altogether, as no contractor will wilfully deviate from his specifications knowing that his work will be sampled and tested. It also gives the contractor an opportunity to prove beyond question that he has followed specifications to the letter and leaves no room for doubt relative to the character of his work. B. G. Cope.

Orrville, O., Dec. 14.

Instruction in Heating and Ventilation

Sir: In your issue of Dec. 7, page 638, Dr. Charles E. Lucke of Columbia University says: "Heating and ventilation as a profession is not at this time recognized in any school of good standing in this country and it is an open question whether the time has yet come to so consider it."

I should like to inform him that heating and ventilation is so recognized in at least two of the good schools of this country, namely the College of Applied Science, Syracuse University, and Purdue University. The course in use at Purdue University you will find described by Prof. James D. Hoffman in the "Transactions" of the American Society of Heating and Ventilating Engineers, Vol. X., 1904. Practically the same system is used in Syracuse University. We find here that the course is of great value, not only in giving the student information concerning what might be called a narrow specialty but also in giving him a good training in the application of arithmetic, elementary physics, mechanics, steam engines and boilers, drafting, etc., to practical use in the design of a plant. This course is given in the second semester of the senior year to all students in mechanical engineering. If the intention were to educate the students more thoroughly in the art and practice of heating and ventilation, the five-year course suggested by Dr. Lucke would be all right, but at present five-year courses are not the fashion. The problem now before us is what studies should be required of a mechanical engineering student during a four-year course; and we teach a partial course in heating and ventilation because we think that every mechanical engineer should be taught something of that subject, whether he intends to specialize in it afterward or not.

Yours truly, Wm. Kent.

Syracuse University, Dec. 21.

Impermeable Concrete.

Sir: During the past few months there has been considerable printed on the permeability of concrete. The subject arises from the use of concrete reinforced with steel; yet, important though it is that concrete to be reinforced shall be nearly impervious to moisture, for the same reason it is important that it shall not crack in tension. Mr. Surtees, in his article in your issue of Dec. 14, p. 661, called attention to one thing: "It has been found that iron cramps after being surrounded with concrete for hundreds of years, have been proved to be in perfect condition, whilst it has been equally proved that steel embedded in concrete floors for only a few years has been affected to such an extent that the wonder was that a collapse had not taken place."

The reinforcement in the floor, surrounded by concrete in tension, was affected, but the iron cramps, surrounded by concrete hundreds of years ago, presumably in compression, were not affected. If a slight tension is produced in the steel of a reinforced concrete beam, the concrete surrounding the steel is put also in tension. If the tensile stress in the steel is increased, the stress in the concrete may be increased enough to crack it a little. Where an engineer designs a reinforced beam, he considers that the concrete does not carry any of the tension. This is done rather in the interest of safety than because of the weakness of the concrete.

We specify that the steel shall be of such and such a tensile strength. Is it not possible for us to specify as well that the concrete shall be so strong in tension as to protect that steel reinforcement, and prevent it from being weakened when the steel does take the stress it is designed to take? A high tensile strength in the concrete would not affect the size of a designed member of reinforced concrete, yet it might be just what would prevent the member from weakening itself. Is it possible to make reinforced concrete members which shall not crack when the steel is in tension? It seems to me that, for the reasons already given, it should be profitable to make a study, by tests, of the tensile strength of concrete of different kinds to settle this point.

Very truly yours,

Benton Lattin.

U. S. Geological Survey Hydrographic Investigations.

Sir: The United States Geological Survey, in connection with its other activities, has been engaged for the past twelve years in making investigations of the quantity, quality and availability of surface and ground water throughout the United States. The results of these investigations have been published regularly as Water Supply and Irrigation Papers and have been available for distribution and for reference in libraries throughout the country. The importance of this work and the value to the public of a knowledge of our water resources has led some of the States, private individuals and corporations to co-operate with the Survey in securing the desired information, and the results of many independent measurements and investigations have been placed at the disposal of the Survey and made available for general use by their publication with the results of the investigations made by the Survey in the Water Supply and Irrigation Papers. The value of this information is by no means limited to the communities in which actual observations are made, as the intelligent study of water yield in various parts of the country, under known conditions of precipitation, temperature, altitude, topography and cultivation, affords a basis for at least approximate determination of the water resources of other localities where no direct investigations have been made, and if the hydrographic investigations are continued throughout the country under the uniform methods and skilled direction of the Geological Survey it may ultimately become possible, with the accumulated data covering seasonal and cyclic variations in stream flow, to formulate general laws which will permit a determination of the water yield in localities where the water resources have not been investigated from the meteorological records of the U. S. Weather Bureau and a knowledge of the topography, extent and nature of cultivation and other factors which are readily ascertained.

It hardly seems necessary to draw attention to the absolute impossibility of developing any part of the country without an adequate supply of water of suitable quality. For domestic purposes, for irrigation, for every class of industrial enterprise, a determination of the availability of an ample water supply is the first consideration. We have never heard any question raised concerning the importance of these hydrographic investigations, their value to the people, nor the thoroughness with which the Survey has done its work, within the limitations of the funds available.

These investigations have been continued during the past twelve years and the appropriations therefor were gradually increased by Congress to $200,000 per annum, which amount was available for four years prior to June 30, 1906. The Committe on Appropriations of the House (59th Congress, Second Session) disapproved of this work and claimed that it had no Federal purpose and should not therefore be supported by the Federal government. The Chairman of the Committee stated: "I do not take issue with the advocates of this appropriation on the question of benefit to the people. The issue which I raise with them is the question of whose duty it is to perform the work." This Committee, in reporting the Sundry Civil Bill, made no provision for this work for the year ending June 30, 1907. An attempt was made on the floor of the House to introduce an amendment, the result of which would have been to provide a suitable appropriation, but a point of order was raised and sustained.

The Senate later approved an appropriation of $150,000 which, in conference between the Committees of both branches, was reduced to $100,000 and the Survey has, therefore, been obliged to carry on the work during the present year for half the amount previously available. The amount of work performed has been proportionately reduced.

In regard to the point of order sustained in the House, it was alleged that the organic act of the Geological Survey does not make any provision for these investigations and that therefore any appropriation for same is without authority in law, notwithstanding the fact that the work has been continued over a period of twelve years under appropriations of Congress.

The Secretary of the Interior has included in his estimate for the year ending June 30, 1909, the sum of $200,000 for hydrographic investigations of the U. S. Geological Survey. The attitude of the members of the present Committee on Appropriations on this subject is not known to us, but in view of the precedent established on the point of order at the last session it is manifestly desirable that a bill be passed giving the Survey specific authority to continue these hydrographic investigations, before the appropriation bill comes up for action.

Such a bill (House Bill No. 6,122) was introduced on Dec. 9 by Mr. Needham "to provide for continuation of investigations of the rivers and water resources of the United States," and will presumably be passed upon by the Rivers and Harbors Committee early in January and soon after acted upon by the House. If this bill is passed, there will be no possible legal objection to the appropriation for hydrographic investigations in the Sundry Civil Bill and the item may then be considered by Congress solely upon its merits when this appropriation bill is taken up later in the session.

In considering the subject a year ago, we wrote as follows:

"It is manifestly impossible for any individual investigators or corporations to pursue such an extended series of gaugings and studies of the laws governing the water resources of the United States as is necessary to establish the relations between rainfall, evaporation, temperature ranges and other climatic conditions affecting the water yield of drainage basins in different parts of the country, and where such local investigations are made by private enterprise the information secured does not ordinarily become available to the interested public, except, indeed, when the data are communicated to the Geological Survey and combined with the results of its own work in the publication of Water Supply and Irrigation Papers.

"It is equally impracticable for the several States to thoroughly cover these investigations, as there would be such lack of uniformity in methods as to prevent the general application of the data thus independently collected, and in the case of the larger streams which bound or traverse several States the net results would probably be so confusing as to be unsafe for practical use.

"The increasing development of all the natural resources of the country is, of course, desirable, but in the case of water, which is indispensable to the prosperity and even the existence of every community, the most complete knowledge should be available in order that it may be intelligently and effectively conserved and utilized for power, for irrigation and for municipal water supplies."

In our judgment this is properly a federal undertaking, equally with the maintenance of the Weather Bureau, the control of navigable rivers, the institution of forest reserves, the surveying and mapping of the United States, and other public works which cannot effectively be undertaken by individuals or the several States. Our knowledge of the great importance of this work therefore prompts us to write this letter recommending your careful consideration of the subject and suggesting that if you agree with our conclusions, you use your influence to secure the uninterrupted appropriation of sufficient funds to ensure the effective continuation of this necessary work and the publication of the results of the investigations for the use of the public.

We trust that Congress will appreciate the real value and propriety of this Federal undertaking and the seriousness of even a temporary interruption of the consecutive observations which are essential to the proper conduct of the work and that House Bill No. 6,122 may be favorably reported by the Rivers and Harbors Committee, become law and that the requested item of $200,000 in the Sundry Civil Bill may be favorably reported and this appropriation thus again become available.

We trust that upon due consideration you will feel prepared to advocate the desired action in this matter, and remain,

Yours very truly,

Sellers & Rippey.

Philadelphia, Dec. 23.

The Moving of a 76-Ton Cupola was accomplished last summer without accident at the plant of the Michigan Stove Co., Detroit. It has a 72-in. shell, is 75 ft. high and lined to the top. Local movers submitted $600 as the lowest bid, but finally a house mover agreed to take the job for $175. Two timbers were placed under the cupola from front to rear and one crosswise. These and the cupola were raised with mover's jack screws until 5-in. wooden rollers and timbers to roll on were placed beneath. A cross timber was fastened by chains to the under timbers, and jack screws between this timber and those under the cupola shoved it along. To insure its being plumb a pole carrying a plumb bob projected from the charging door. A plank fastened to the base of the cupola had a nail in it which was directly beneath the plumb bob, when the cupola was vertical, and the swinging of the bob therefore showed how to raise the blocking. After everything was ready the cupola was moved in 10 hours. The mover is stated to have made a profit of $75. The work was described in the paper on the new foundry of the Michigan Stove Co. presented at the recent convention of the American Society of Mechanical Engineers.